Electronic Design®

VOL. 28 NO. 7

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

MARCH 29, 1980

Opto-coupling teams up with VMOS for super performance

**Special Report:
Logic analyzers sharpen their wits**

Wade through logic streams with today's analyzers

Cut input current with BIMOS op amps

Design practical 200-kHz switchers

To meet MIL-STD-1553A you're going to need some "SMARTs"

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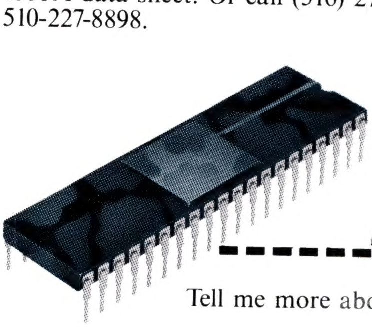

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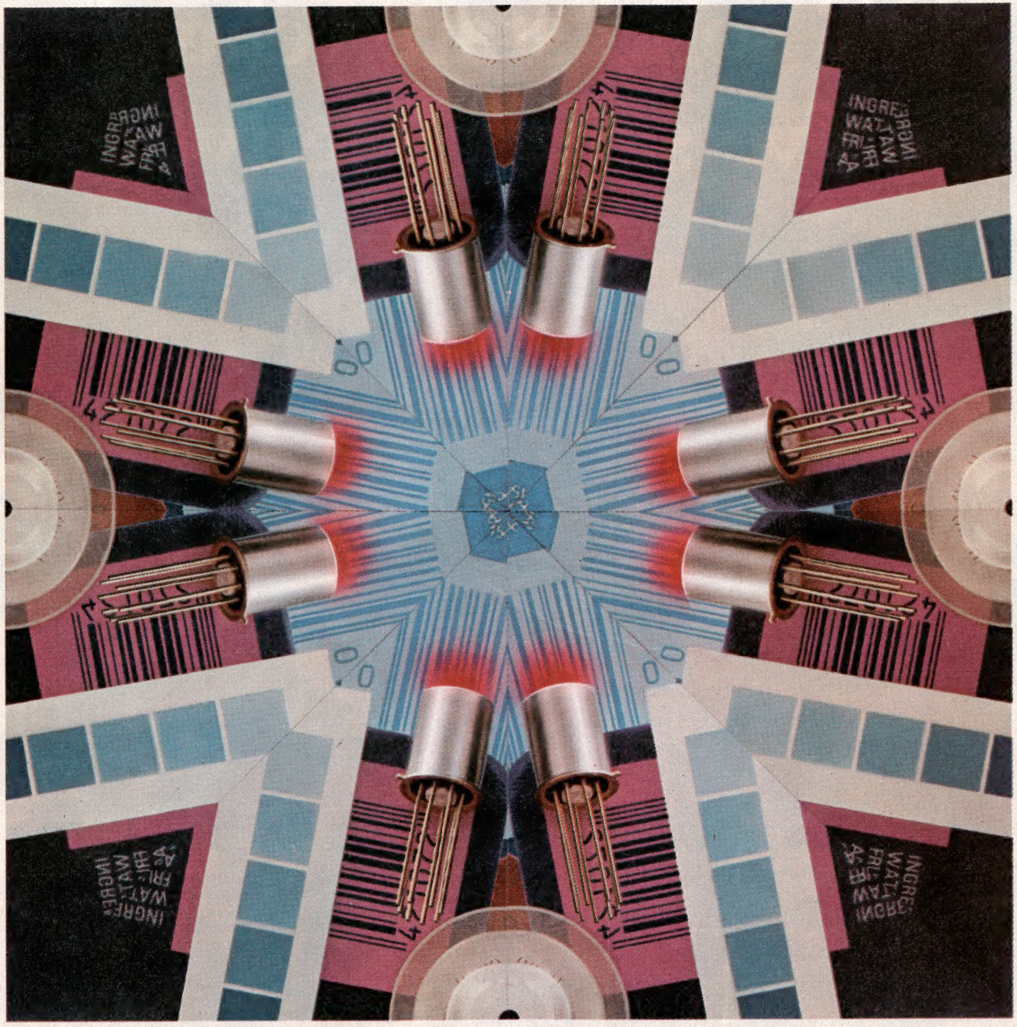

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SSR UPDATE

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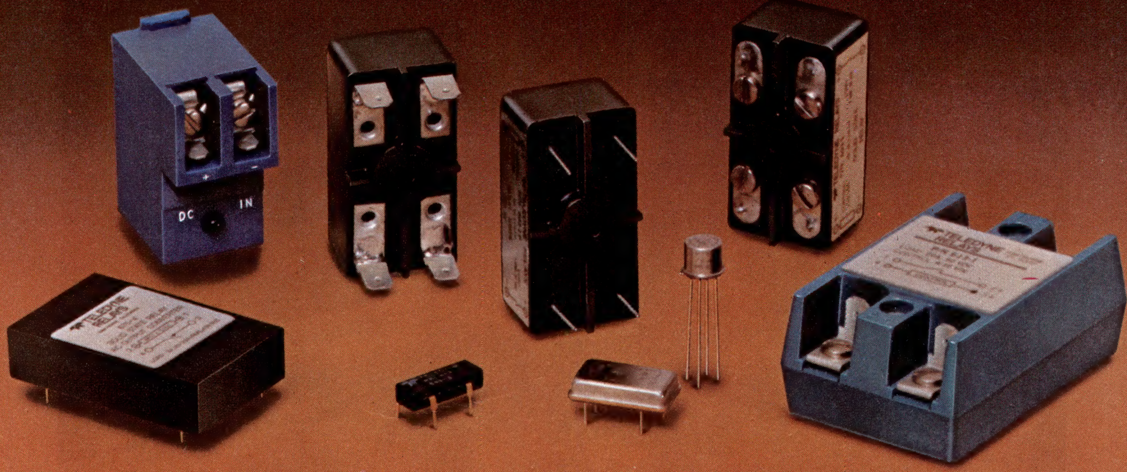

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CIRCLE NUMBER 4

Contents Spotlight

Special Report: Logic analyzers meet growing test challenge

Logic analyzers are rapidly taking on more and more features—with growing testing needs stepping up the demand for both general-purpose and specialized test equipment, they have to. The list of capabilities is lengthening: Microprocessor-bus demultiplexing, selective triggering, analog channels, field-service availability and production testing are making LAs a fixture in the digital world, as they also move into the analog world.

p. 48

Optocoupling, power-MOS SSRs make speedy, long-life switchers

Solid-state relays that combine optical coupling for high isolation with the fast switching speeds of a power MOSFET can switch high-voltage loads faster than reed relays and phototriacs. The OptoMOs devices from Theta-J Corp. (Woburn, MA) offer not only switching speeds as low as 10 μs but also on resistance less than 20Ω (for the first member of the family) and isolation better than 7500 V between control and load signals. What's more, with their solid state, the speedsters could last through more than 50-million operations.

p. 60

Dual-channel electrometer/DMM handles low input levels

The industry's first dual-channel electrometer/multimeter gives the ratio or difference of two input signals at the push of a button. It supersedes the expensive arrangements of hardware previously required—an electrometer, multimeter, control electronics to tie into the IEEE-488 bus and a picoammeter—to handle delicate measurements with good sensitivity, resolution, accuracy and precision.

p. 67

Logic analysis steps up to multiplexed μPs

Multiplexed microprocessors create new problems in logic state analysis. An analyzer geared for sorting out the logic flow on multiplexed μP buses must trigger simultaneously on specific address and data information; sort the information for selective editing; display the read and write instructions and data as originally programmed; and make functional measurements on the state flow. How does it do all this?—With specially added status and control lines that coordinate the logic analyzer's attack.

p. 89

Using a logic analyzer to its fullest

Logic analyzers have many facets: They collect, trigger and pretrigger on state, time and waveform events, often simultaneously. But an analyzer solves problems only if the designer capitalizes on all its potential by interpreting the data it turns up. A step-by-step investigation of a crashing disk demonstrates how a designer must guide the logic analyzer.

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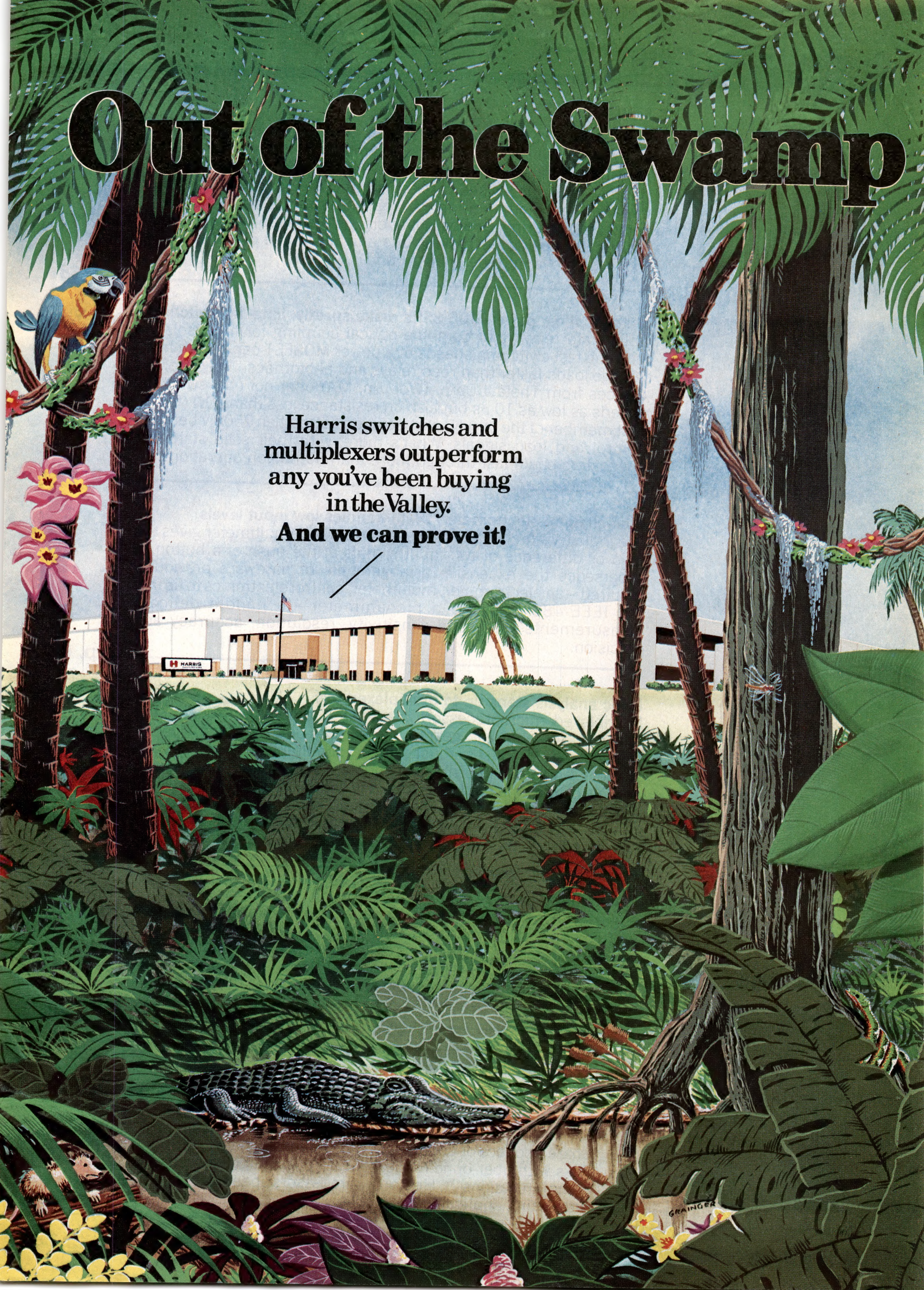
Featured Next Issue

In the April 12 issue:

Special Issue on Communications . . . Designing data-comm systems with multichip modules and boards . . . First details on a telecomm support chip . . . Introducing a multiprotocol data-comm chip . . . Shared codecs or codec-per-line? Guidelines help . . . Replacing wire links with fiber-optic modems . . . Choosing light sources for optical communications . . . How array processors speed data flow in signal-processing applications.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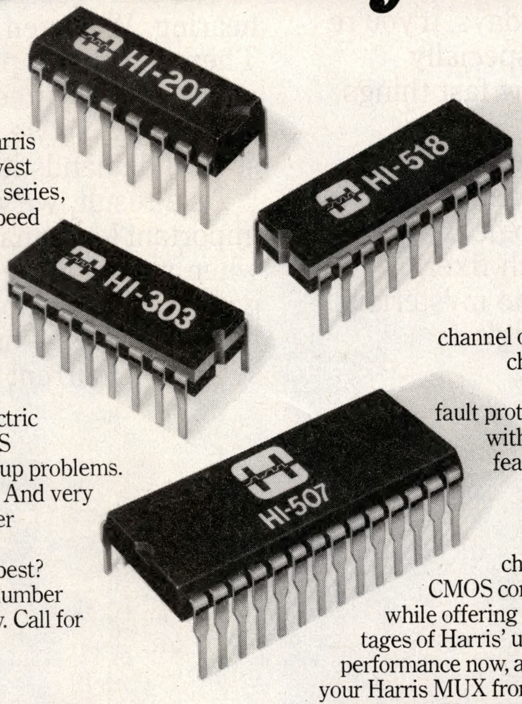

Swift switches.

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DG 300	HI-300
DG 301	HI-301
DG 302	HI-302
DG 303	HI-303
DG 304	HI-304
DG 305	HI-305
DG 306	HI-306
DG 307	HI-307

Competitive Part Number	Harris Pin-for-Pin Replacement
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IH 5041	HI-5041
IH 5042	HI-5042
IH 5043	HI-5043
IH 5044	HI-5044
IH 5045	HI-5045
IH 5046	HI-5046
IH 5047	HI-5047
IH 5048	HI-5048
IH 5049	HI-5049
IH 5050	HI-5050
IH 5051	HI-5051

ANALOG MULTIPLEXERS

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DG506BR*	HI1-506-5	HI1-506A-5
DG506CJ	HI3-506-5	HI3-506A-5
DG507AR	HI1-507-2	HI1-507A-2
DG507BR*	HI1-507-5	HI1-507A-5
DG507CJ	HI3-507-5	HI3-507A-5
DG508AP	HI1-508-2	HI1-508A-2
DG508BP*	HI1-508-5	HI1-508A-5
DG508CJ	HI3-508-5	HI3-508A-5
DG509AP	HI1-509-2	HI1-509A-2
DG509BP*	HI1-509-5	HI1-509A-5
DG509CJ	HI3-509-5	HI3-509A-5
No comparable parts	HI1-516-2	—
No comparable parts	HI1-516-5	—
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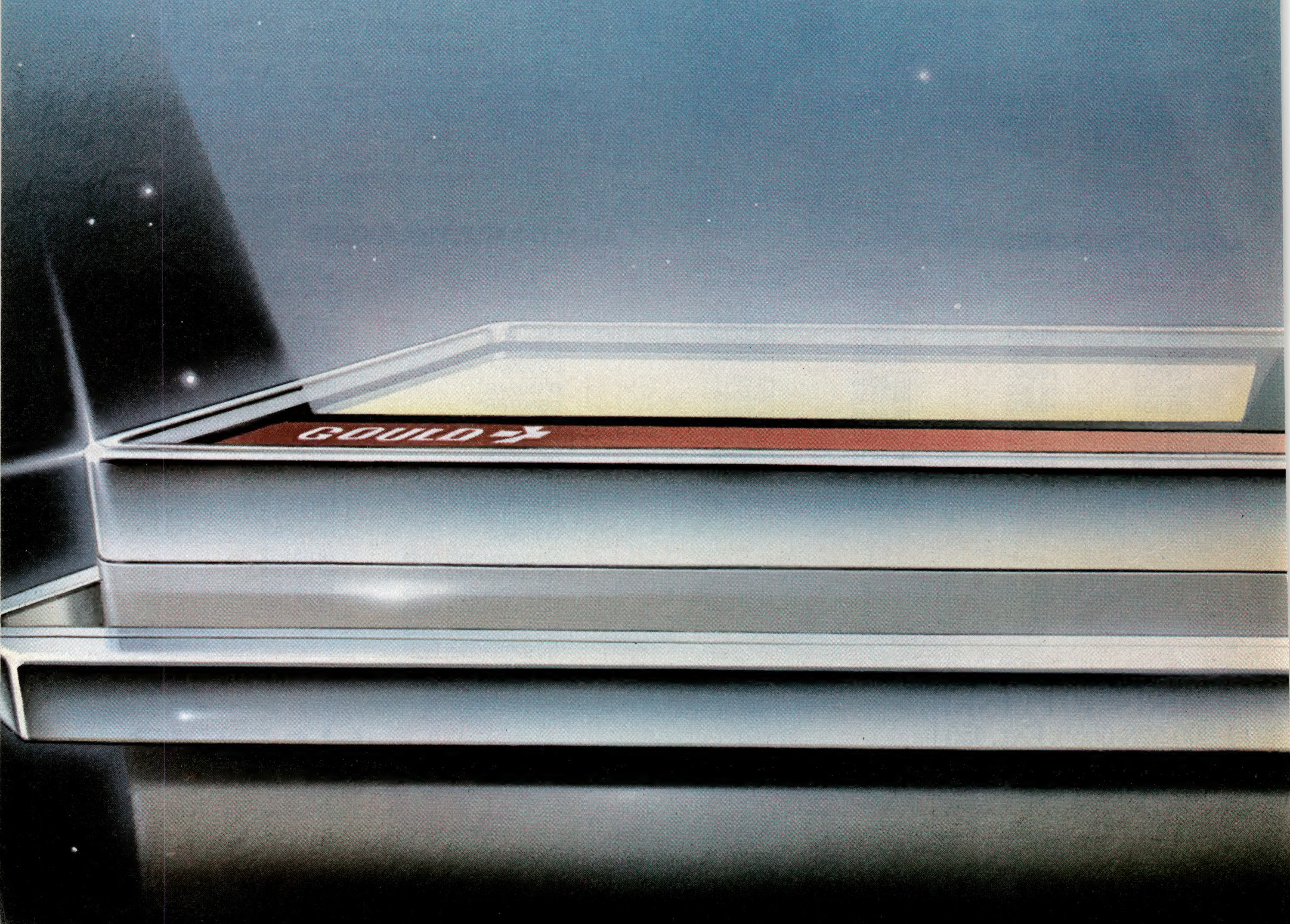

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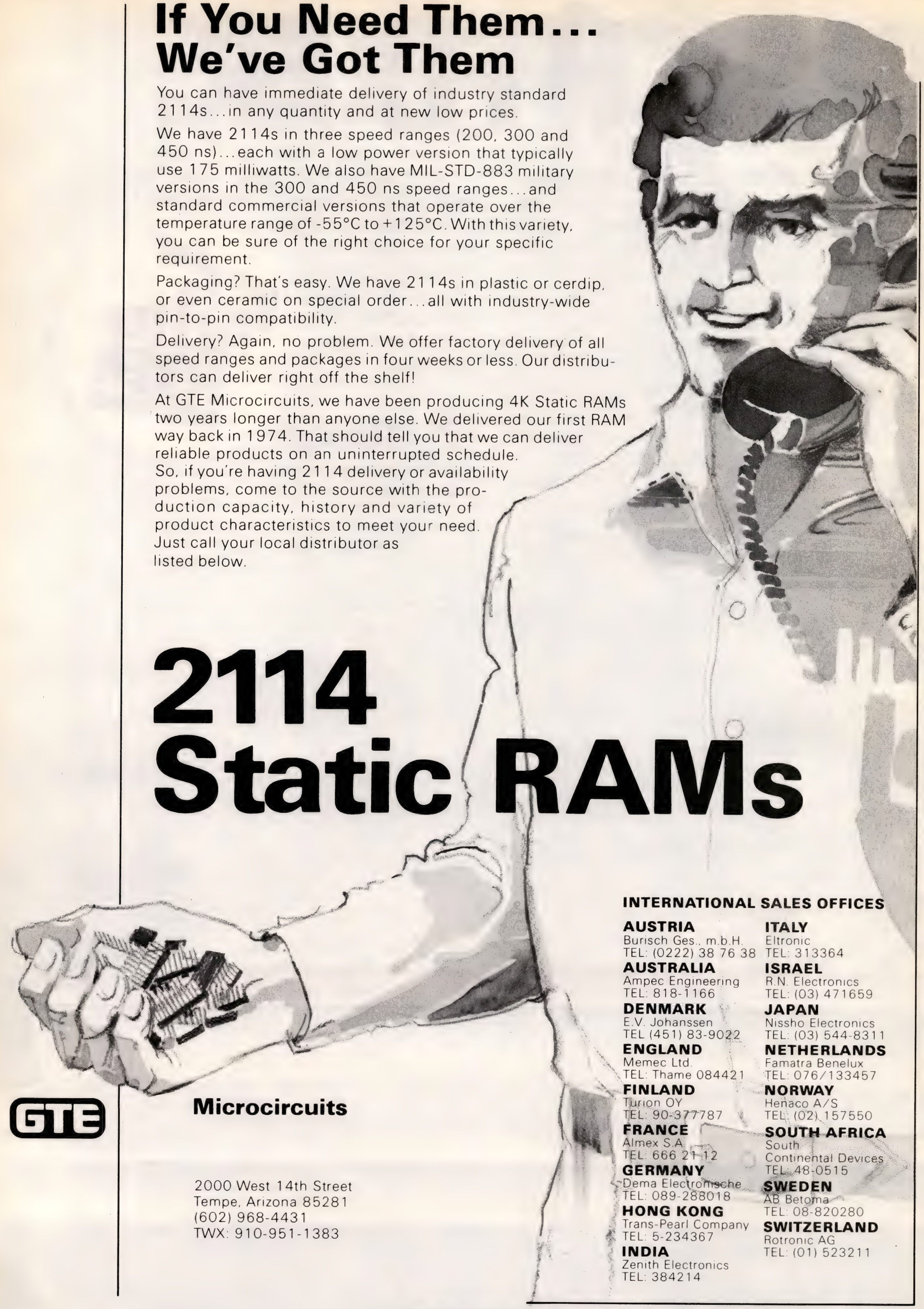

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CIRCLE NUMBER 7

Reader Feedback

Patent-reform funding is paltry

Your editorial about IEEE's faulty allocation of funds for its professional activities (Dec. 20, 1979, p. 39) was well stated. Particularly upsetting is the small sum ($16,400) spent to liberalize the patent law. Influencing legislation that would permit the engineer/inventor to share in the benefits of the invention is particularly important in view of President Carter's recently expressed concern about the decline of American innovation.

Bruno Weinschel, IEEE's Vice President for Professional Activities in 1978 and again in 1979, appointed patent attorney Howard Rose to head IEEE's efforts in this area. One of Mr. Rose's clients is—you guessed it—Weinschel Engineering Company, which derives about $75,000 per year from patent royalties.

Because of the nature of its hierarchy (academics and corporate executives), IEEE has done little to further the interests of the American working EE.

Irwin Feerst

Committee of Concerned EEs
P.O. Box 19
Massapequa Park, NY 11762

Mr. Weinschel replies

IEEE is quite concerned about the lagging productivity and innovation in the U.S. and believes that utilizations of patents would be helped by giving the title to the inventors wherever possible.

The patent task force of the IEEE's United States Activities Board, under the chairmanship of Howard Rose, assisted for the second year in the redraft of Senator Birch Bayh's Bill S.414, which assigns title of patents stemming from government-sponsored R&D to small business and to nonprofit institutions. The task force also has drafted a proposed model agreement between employers and engineers, clarifying many murky areas that otherwise would have given the employer automatic control of a patent. It is currently being commented on by all IEEE technical groups and societies as well as sections. Within a few months, the comments will be coordinated with the task force to reflect the consensus.

The IEEE patent task force is very fortunate in having a man of Howard Rose's caliber, who not only has experience in the industrial field but also has been a patent examiner and Chief Patent Attorney for the National Bureau of Standards.

I am no longer connected with the United States Activities Board. However, its new Chairman, Dr. Richard Gowen, Dean of Engineering and Vice President of the South Dakota School of Mines and Technology, was very fortunate to secure the continuation of Howard Rose's services as task-force leader for patents.

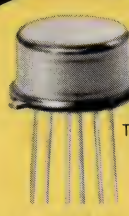
Technology pushes on

Your speculations on minicomputers in the Technology Forecast issue (Jan. 4, 1980, p. 98) were interesting. Of course, accurate forecasting in the computer industry ranges from problematic to nearly impossible, given the cross-pressure from technology push and economic squeeze.

Talking about technology push: I know you can't follow every advance, but in the VAX-11/780 column of your profile table, the main memory capaci-

(continued on page 14)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.



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NAGEL

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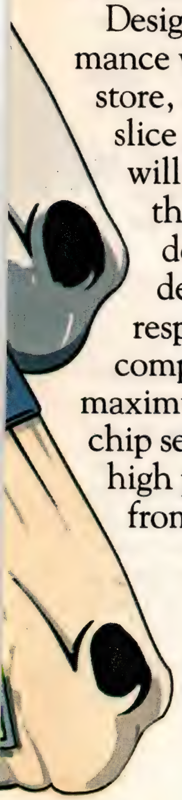
2149H-2	45ns	20ns	180mA
2149H-3	55ns	25ns	180mA
2149HL-3	55ns	25ns	125mA
2149H	70ns	30ns	180mA
2149HL	70ns	30ns	125mA
2148H-3	55ns	55ns	180mA/30mA
2148HL-3	55ns	55ns	125mA/20mA
2148H	70ns	70ns	180mA/30mA
2148HL	70ns	70ns	125mA/20mA

There's a fast new pace in wide-word memory, and Intel's two new 1Kx4-bit static RAMs are way out in front. Introducing the high speed, lower power 2148H and the fast chip select 2149H. They're both products of Intel's HMOS II technology and both are high performance descendants of our industry standard 4K x 1-bit 2147H. Best of all, Intel's track record in static RAMs assures you of the quality, reliability, economy and delivery you need for today's competitive system designs.

Fast break for wide-word designs



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Pull ahead today

Intel's new 2148H and 2149H are in volume production and on distributor shelves today. So are data sheets and our new HMOS II Reliability Report, #RR26. To get a head start on your competition, contact your local Intel sales office or distributor. Or write Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Or call (408) 987-8080.

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CIRCLE NUMBER 26

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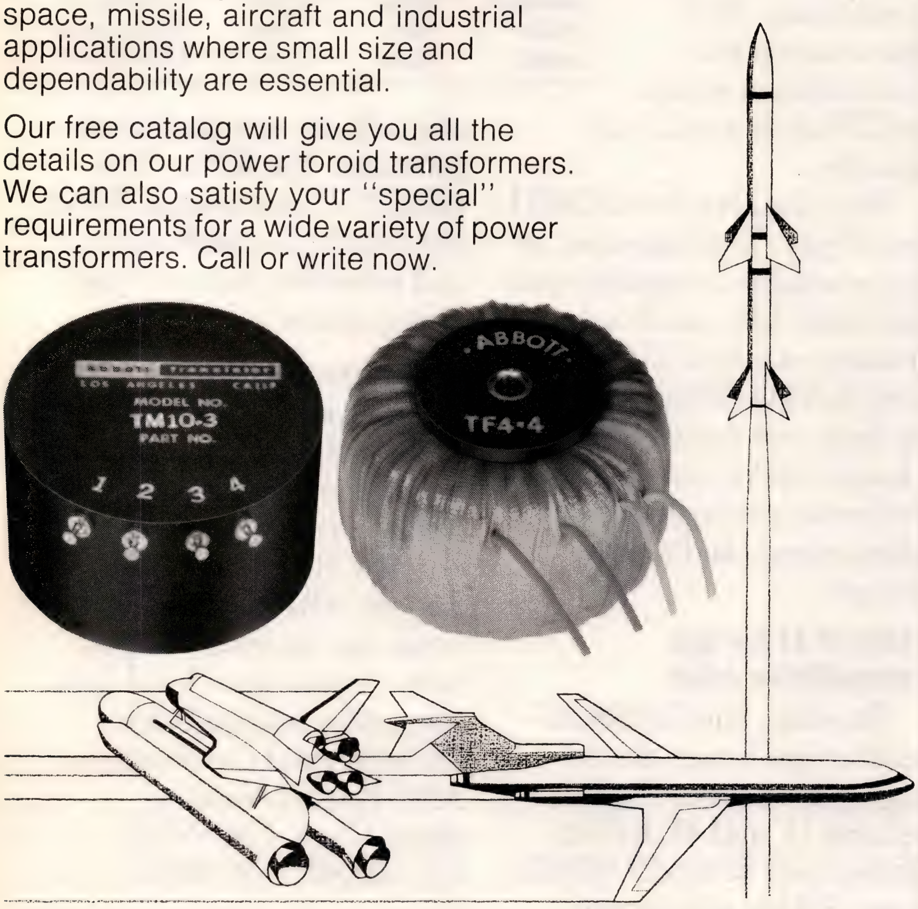

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CIRCLE NUMBER 9

Reader Feedback

(continued from page 11)

ty should read 8 Mbytes, not 2 Mbytes, because of the substitution of 16-k memory chips for 4-k chips. Also, with the MA790 multiport memory option, the maximum available physical memory per processor in multisystem configurations can be raised to 12 Mbytes (8 Mbytes local plus 4 Mbytes shared).

The quoted I/O transfer rate of 2 Mbytes per second is correct for a system with only one MASSBUS channel. However, the VAX-11/780 will support up to four MASSBUSes and up to four UNIBUSes, giving a maximum I/O transfer rate of 13.3 Mbytes/s (limited by the bandwidth of the synchronous backplane interconnect).

McLaren Harris
Public Relations Dept.
Digital Equipment Corp.
129 Parker St.
Maynard, MA 01754

On a chemical matter

In the Feb. 15 Reader Feedback column (p. 11), Mr. Rustenberg is mistaken in saying that iridium is not a chemical. All matter is one chemical or another, and certainly iridium is matter.

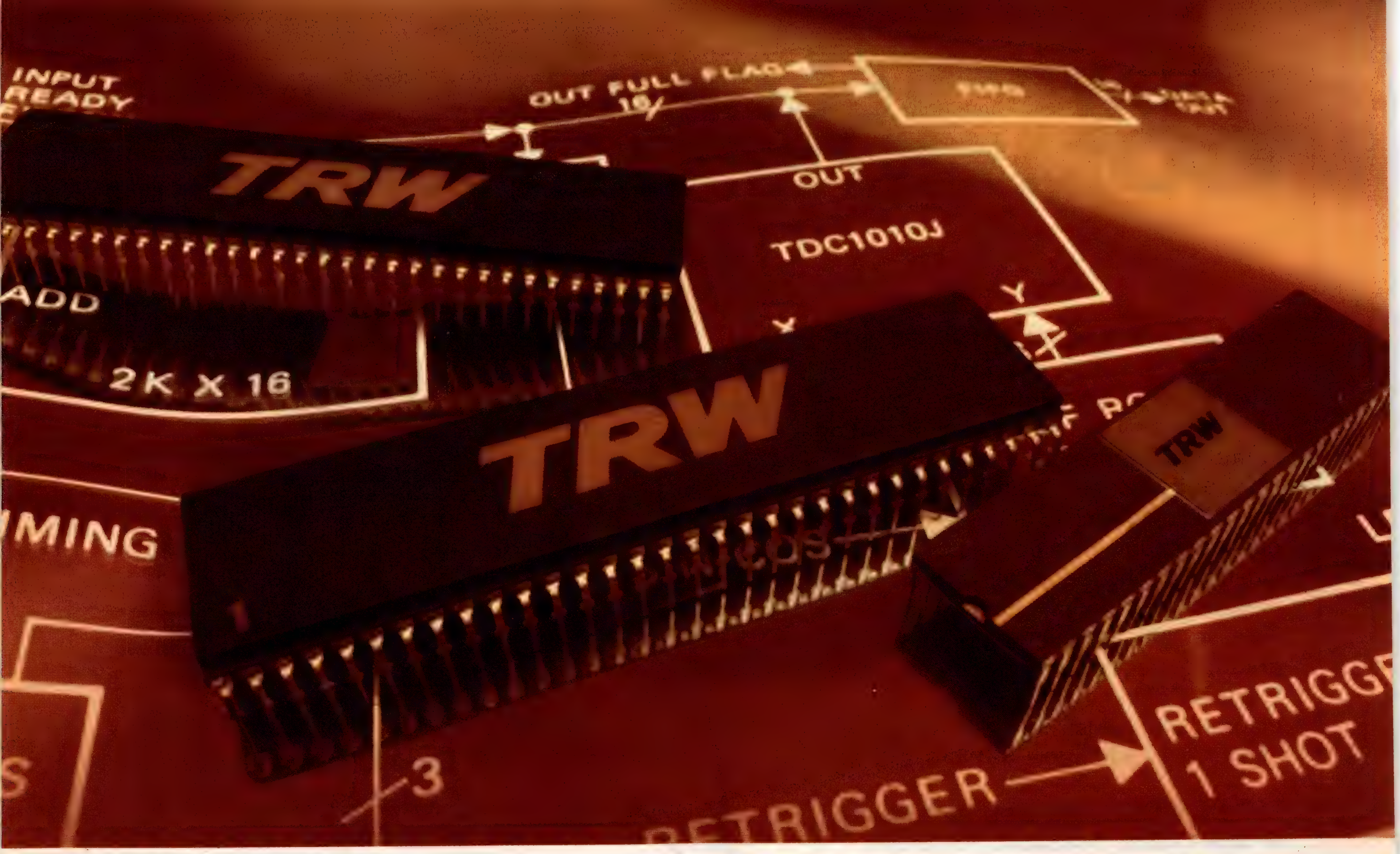
The *Handbook of Chemistry and Physics*, a venerable reference, describes iridium as being a member of the platinum family, white in color, similar to platinum, but with a slight yellowish cast. The melting point is shown as 2410 C (4370 F).

Leonard E. Herzmark, PE
Bureau of Water Quality Control
Arizona Dept. of Health Services
Phoenix, AZ

Continuous, not peak

Your article about solar cells (Jan. 18, 1980, p. 38) described the performance of solar cells in terms of cost per peak watt. The reference to peak watt does not appear to be appropriate since most applications would require power to be supplied for prolonged periods. It would be more appropriate to describe the performance in terms of continuous power.

Stanley Walter
Electronics Engineer
Simmonds Precision
Instrument Systems Div.
Panton Rd.
Vergennes, VT 05491



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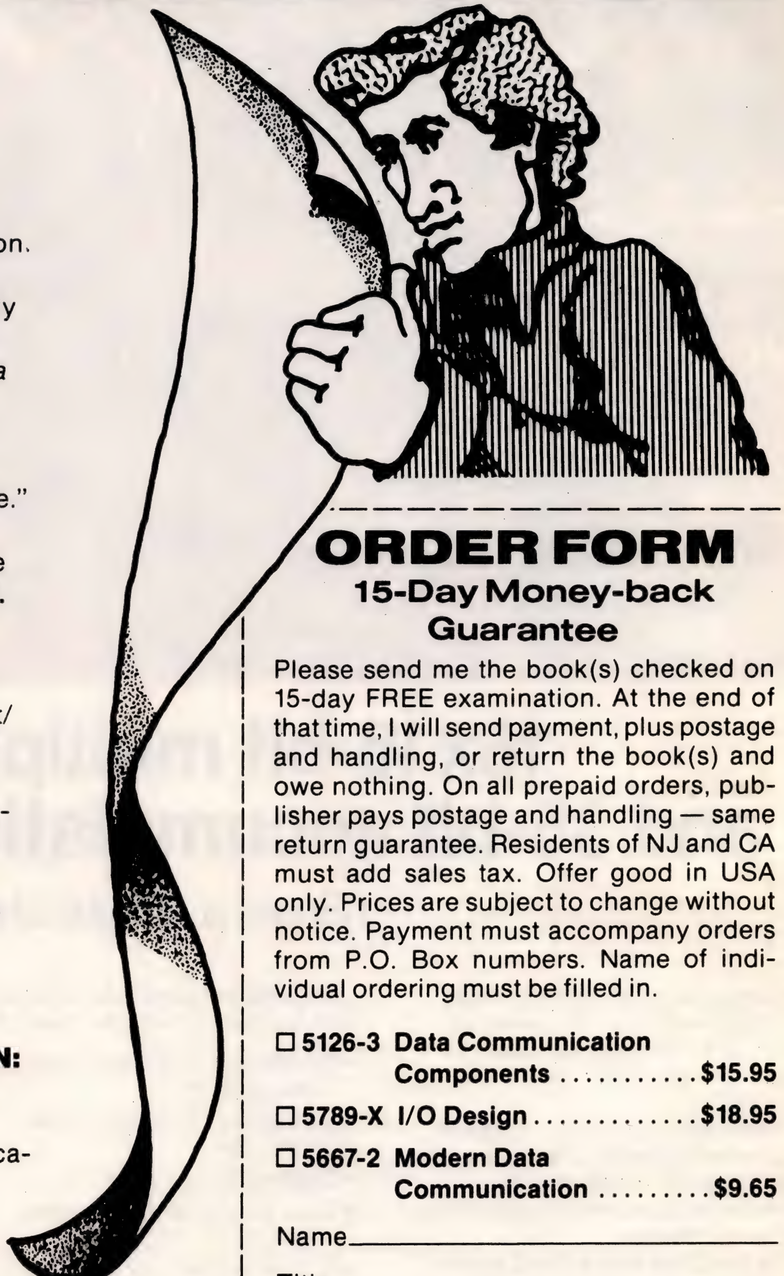

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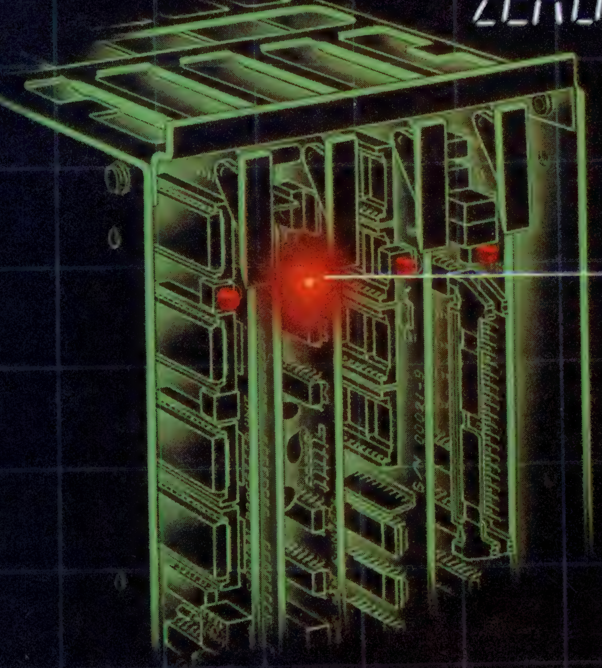

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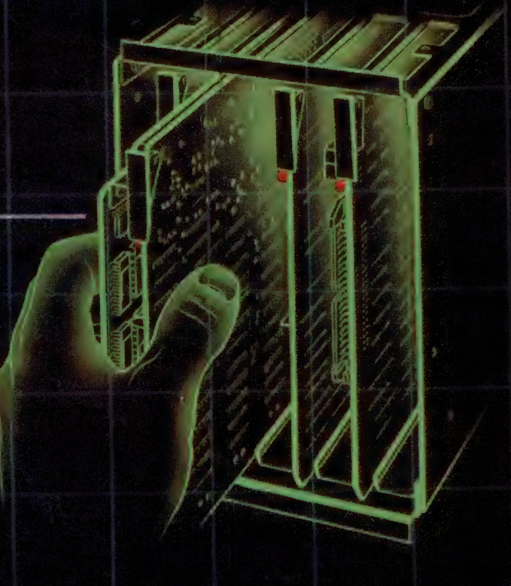

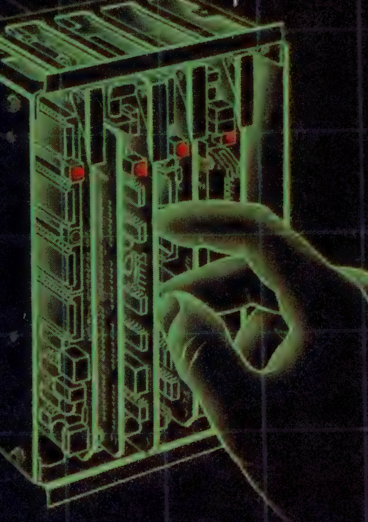

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If your current project is microprocessor based, the 3300 can prove useful as a substitute clock-pulse generator. It's capable of driving several related instruments or circuits independently. One of the most interesting applications for this instrument is to transform an ordinary triggered sweep scope into a delayed-sweep scope. We've designed in a fixed delay mode for quick set-up.

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CIRCLE NUMBER 13 For Free Demonstration
CIRCLE NUMBER 14 For Additional Information

Dynamic-memory support chips detect/correct errors

Three major LSI circuits—a dynamic memory controller (DMC) and an error detection and correction circuit (EDC) as well as a refresh-timing and error-control circuit for the Z8000 CPU (RTEC)—will spearhead a family of circuits that can support any memory system. Breaking dynamic memory-support functions into general-purpose building blocks, Advanced Micro Devices (Sunnyvale, CA) has put together two functionally identical sets: the Am296X series, for operation with bipolar bit-slice circuits, and the AmZ816X series, for MOS microprocessor systems such as the Z8000.

Special buffers and line drivers have already been developed to support the memory data and address buses. Four octal buffers, the Am2965/66 and the AmZ8165/66, will drive the address lines—two buffers have inverting outputs (the 65s) and two have noninverting outputs (the 66s). All the buffers are pin-compatible with the 74S240/244-type units that come in 20-pin DIPs.

Also planned are special data-bus buffers that will come in 4-bit sections but offer four 4-bit ports that permit the EDC to interface to the memory and data bus. Expected to be housed in 24-pin 300-mil skinny DIPs, the buffers (Am2961/62 and AmZ8161/62) will come with the inverting or noninverting data-bus port outputs.

In a typical memory system, the DMC and address-line buffers will connect between the CPU and the memory-array address lines, while the data-bus buffers and the EDC will interface the memory array's data-I/O pins to the system data bus. In Z8000 systems, the RETC will interconnect the CPU timing, memory-array refresh control, and error-detection logic to provide all the "glue" for a system as well as provide a few extras such as error logging and processor-interrupt capability. In non-Z8000 systems, the equivalent functions can be implemented with MSI.

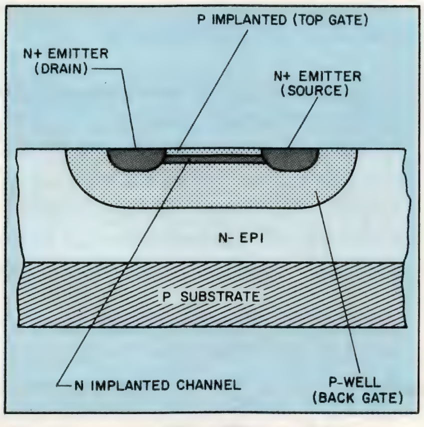
The DMC will handle either 16 or 64-k dynamic RAMs, and provide either 128 and 256 refresh cycles, depending on the RAMs selected to build the system. The EDC will perform multiple-error detection and single-bit error correction. Multiple EDCs can be cascaded, with each to handle a 16-bit word. In a 16-bit system, six additional check bits are needed by the EDC. In a 32-bit system, a seventh check bit must be used, and in a 64-bit system an eighth bit is required.

The DMC (Am2964/AmZ8164) will be sampled in late April, while the EDC (Am2960/AmZ8160) will be sampled in the late third quarter. The RTEC will follow even later in 1980.

N-channel BiFET op amps run on single supply

An advance in op-amp circuitry combines n-channel junction-FET devices with bipolar devices on the same piece of silicon. The result is the TL090 series of BiFET op amps (Texas Instruments, Dallas, TX) that operate from a single supply voltage of 7 to 10 V. The N-FET technology allows the op amps to process signals at or near the ground level.

Compared to other single-source and BiFET op amps, the TL090 series has significantly better distortion characteristics and the same high-input impedance (10^{12} Ω typical). The minimum common-mode rejection is 70 dB, which allows the input to amplify signals close to the negative rail. The op amps look for signal levels that are 3 V or more above the ground plane or the negative rail to ensure good common-mode rejection.



Two implants allow TI to build N-channel junction FETs and bipolar devices on the same substrate.

Three versions of the TL090 series will be available later this year. The TL091 is a single op amp, the TL092 is a dual op amp, and the TL094 is a quad version. All of the op amps have a slew rate in the vicinity of 3 V/μs, a bandwidth of 1 MHz open-loop and noise below 30 $nV-\sqrt{Hz}$ at 1 kHz.

DMMs, switch elements improve wafer testing

Having recently introduced systems for checking the operation of test devices placed on semiconductor wafers during manufacturing, Keithley (Cleveland, OH) and Lomac (Santa Clara, CA) are already coming forth with performance improvements.

Both the System 2A (Keithley) and the earlier LM-80X (Lomac) give a manufacturer a means of determining whether or not the entire wafer is bad before carrying out further costly wafer processing. But now, the new System 2A contains the company's latest electrometer/picoammeter, the 619 (see p. 67), which offers a new switching matrix and employs a new and faster minicomputer for processing test results. These improvements, according to Steve Bottorff, a Keithley Marketing Engineer, include faster measurements, better sensitivity and lower system cost.

Like its rival, the LM-80X sports a new digital multimeter as well as a new matrix for higher speed and better accuracy, and additions to its data-processing capability for better processing throughput. At the same time, the new LM-80X also offers power-supply enhancements that, when combined with the improved DMM, increase system speed ten times, according to John Lally, Lomac marketing manager.

With *its* new meter, says Keithley's Bottorff, the System 2A takes measurements twice as fast, while sensitivity increases by an order of magnitude from 1 pA to 1/100 pA. And system cost comes down because the 619 replaces three instruments.

Besides adding faster test speed and greater accuracy to the System 2A, the switching matrix provides better capacitance measurement capability. Speed in the switching element is improved by using a three-wire fully guarded Kelvin matrix instead of a two-wire matrix. Accuracy is also better because there are less connectors and few jumpers. In terms of numbers, the errors introduced by the new matrix are 10 pA or less, compared to the previous 100 pA.

Capacitance measurements that used to require dedicating two pins of the matrix are now permitted through the switching element.

Finally, the new system 2A uses a DEC PDP-11/23, which increases data-processing speed five times over the original system.

The new LM-80X's switching matrix also uses the three-wire driven-guard technique and boasts a ten-times speed increase, according to Lally. Additions to the data-processing capability of the new system include a parallel ALU module, called PALM, which Lally says helps improve throughput 30 to 40 times by unburdening the system's CPU, a Z80.

Operating system, Pascal improve for Nova

The MP/OS operating system with MP/Pascal, originally released for MicroNova (ELECTRONIC DESIGN, Oct. 11, 1979, p. 28), now supports multitasking, dynamic-link string types, dynamic memory management and interfaces with assembly language, among others. In its enhanced version, it supports the Nova 4 line and is a compatible subset of Data General's advance operating systems (AOS), for the Eclipse series.

The MP/OS and MP/Pascal real-time programs now serve a wide range of systems, from the smallest microNova to the largest Eclipse. A reduction in program-development and modification costs, more efficient code and an increase in software reliability are the valuable byproducts of the enhancement.

Briefs

With a hand-held scientific keyboard, two internal microprocessors and a plug-in memory module, the 8860A benchtop/portable DMM from John Fluke (Mountlake Terrace, WA) carries considerable measuring capability. Because it is user programmable the instrument resembles a scientific calculator more than a multimeter. On-board features includes 50 data registers, RPN notation, label addressing, subroutine capability and conditional branching, for such applications as statistical analysis, data logging, signal averaging and linearizing. Programs and data flow back and forth between the keyboard, removable memory module and DMM mainframe; so the user gets flexibility in collecting, manipulating and displaying or printing results.

Unusual reliability comes from 50-A and 100-A Darlington switches, under development at General Electric's Components Division (Auburn, NY). The 50-A (125-W), 450-V, D66DV and 100-A (312-W), 450-V D67DE switch within 10 μs and are operable within −40 to 150 C. The single-chip Darlingtons are intended for ac motor controls, and industrial process controls.

An 8-bit family of microprocessor-compatible d/a converters welcomes a 10-bit addition—the NE5020 from Signetics (Sunnyvale, CA). The d/a converter operates with little external support, because it contains its own ladder and switches, output amplifier, internal band-gap reference and input data latches. Samples should be available in the next few weeks, priced from $12 in 100-unit lots.

Reverse operation turns an eight-channel analog multiplexer into an analog demultiplexer. Originally designed for shared-channel codecs, the DMX-88 from Precision Monolithics (Santa Clara, CA) reduces noise levels by contributing a maximum of only 24-pC on each output.

A double-window fiber from Corning (Corning, NY) allows fiber-optic transmissions at both 850 and 1300 nm. The Corguide 3008D glass fiber is 125-μm OD with a core diameter of 50 μm. The attenuation of the fiber is 3.0 dB/km at the 850-nm window and less than 1.5 dB at the 1300-nm window.

A precision thin-film resister network will take over most of the scaling operations on the front-end of low-cost d/a converters. The 694-3 resistor network from Beckman Instruments (Fullerton, CA) provides four precision resistors (0.1% tolerance) in an 8-pin DIP package, with ratios to within 0.05%, tempcos better than 50 ppm/°C and temperature tracking to within 5 ppm/°C over the temperature range of −65 to 125 C.

For less than $1000, a thermal printer provides 256-dot resolution in a full 44 columns. The Microplot 44 from Gulton Industries (East Greenwich, RI) is compatible with RS-232C or IEEE-488 buses. It transforms digital information into alphanumerics, using any one of 96 ASCII character codes, or into graphics on a 44 × 22-dot X-Y plot.

A second-source agreement between Texas Instruments (Dallas) and ITT Intermetall (Freiburg, West Germany) makes Intermetall an alternate worldwide source for TI's 16-bit TMS 9900 μP family and TI a worldwide second source for ITT-developed consumer and automotive ICs. The ITT CMOS, PMOS and bipolar circuits include remote-control transmitters and receivers, TV channel selectors and TV character generators. TI will provide ITT with seven CPU chips and 15 peripheral circuits.

Nebula, a machine-independent operating system, efficiently executes the Defense Department's new general-purpose language, Ada. Nebula was developed by Carnegie Mellon University (Pittsburgh, PA) for the U.S. Army Communications Research and Development Command (Fort Monmouth, NJ). The architecture of the Nebula instruction set accommodates 32-bit addressing and nearly 5-billion bytes of memory.

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CIRCLE NUMBER 15

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The Blue Max dipped monolithic ceramic capacitor is one reason why Analog Devices has been able to build outstanding performance and low cost into their AD2036, a new 6-channel scanning digital thermometer.

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CIRCLE NUMBER 16

Medium-power devices mark breakthroughs in MOSFET

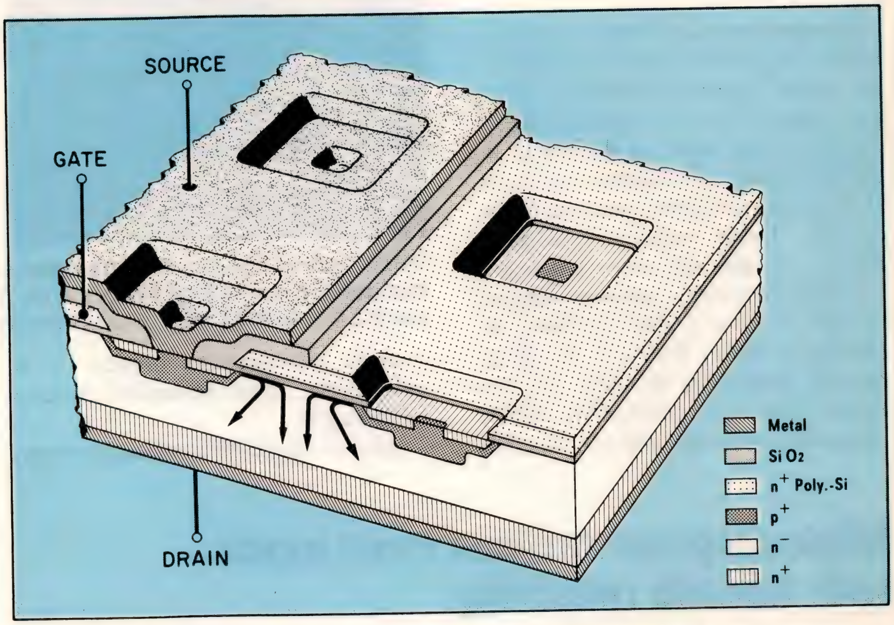
Medium-power devices from two manufacturers of semiconductors take advantage of standard and innovative approaches to power MOSFET technology. Texas Instruments (Dallas, TX) fabricates its 40, 60 and 80-V devices with popular VMOS technology, featuring high input impedances and fast switching speeds. A new vertical DMOS technology employed by Siemens AG (Munich, West Germany) makes its devices compatible with the TTL outputs of many LSI and VLSI components.

SIPMOS, Siemens' breakthrough in power MOSFET technology, significantly lowers the input current required to turn on a device. The company's 12-A, 50-V BUZ 10 and 8-A, 100-V BUZ 20 switch with less than 1 mA at 5 V at the gate.

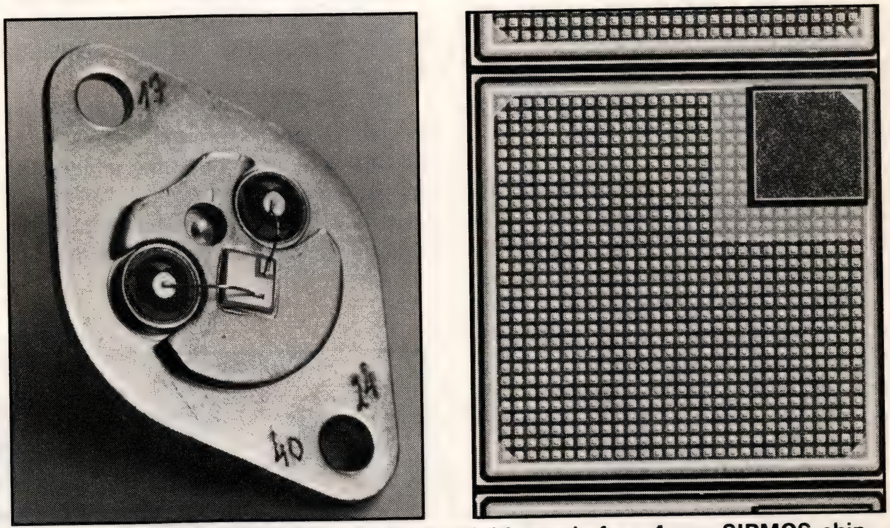
In addition to very small turn-on currents, the new devices offer unusually low on-resistance: typically 0.01 Ω for the BUZ 10 and 0.2 Ω for the BUZ 20. Both will be available initially in TO-220 plastic packaging. Future versions of the 8-A device (BUZ 23) will come in TO-3 cans.

Other SIPMOS devices under development accommodate drain-source voltages up to 1000 V for power utility companies. Also under development are devices which will harness the SIPMOS technology to high-speed, medium-power thyristors and triacs.

The SIPMOS devices employ a vertical DMOS technology consisting of an n^- doped silicon epitaxial layer, with two implants (a p^+ barrier zone and an n^+ source) covered by a metallized n^+ polysilicon gate. The gate forms a grid of 3000 cells on each 4 × 4-mm chip. High-purity silicon, formed by float-zone pulling of the raw silicon stock, accounts for the unusually small turn-on currents and the unusu-



The vertical DMOS technology employed in SIPMOS devices from Siemens requires double implants on an n^- epitaxial layer. With high-purity silicon, turn-on currents and on-resistance are unusually low.



More than 3000 DMOS cells are implanted in each 4 × 4-mm SIPMOS chip. Although initially available in a TO-220 case, a TO-3 packaged device (left) will be available later in the year.

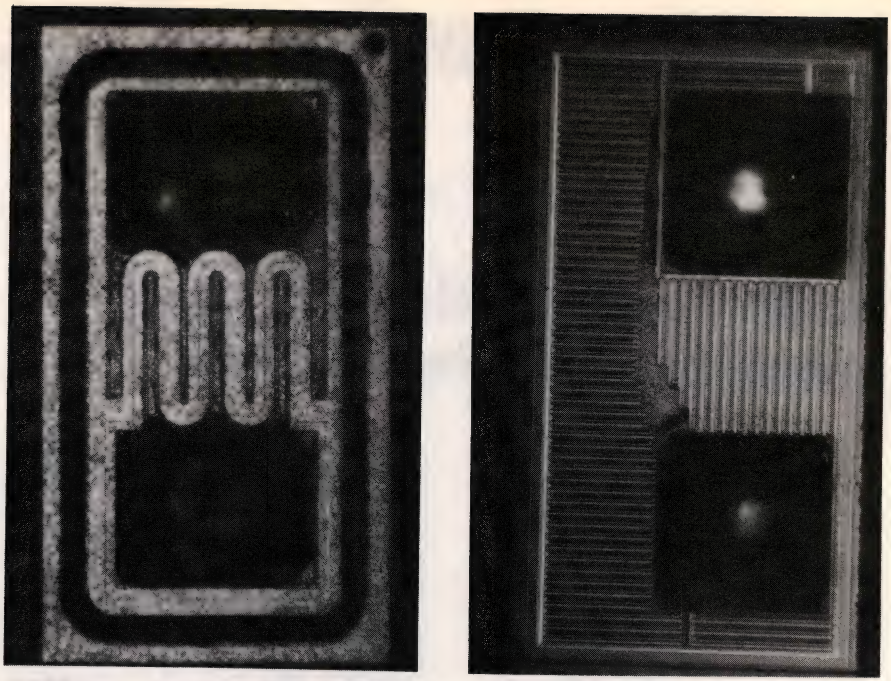
Stephan Ohr
Components Editor

ally low on-resistance.

A more conventional V-groove technology produces the 40-V, 3-A TIPF101, 60-V, 2.5-A TIPF102 and 80-V, 2-A TIPF103 from Texas Instruments.

The TIP-F series comes in TO-220 packages and offers a typical on-resistance of 1 Ω. With an on-state drain-to-source voltage of 10V and rated current, the gate-to-source voltage is 1.7 V for the 3-A device, 1.9 V for 2.5-A device and 2.2 V for the 2-A device. Switching speeds are exceptionally fast: 10 ns for turn-on 15 ns for turn-off.

As announced at Powercon in San Diego, CA, these relatively low-priced, low-power devices can replace relays and relay drivers in automobile applications and serve as drivers to interface CMOS with bipolar output devices in motor-control and amplifier circuits. Later versions will offer higher voltages and current ratings.



VMOS technology uses finer linewidths than bipolar, as shown, in this comparison from Texas Instruments. A 40 × 70 mil bipolar chip (left) can carry 2 A at 40V; a VMOS chip of the same size carries 3 A at 40V.

VMOS technology, however, may not be used in later production runs, according to Henry Moomaw, Jr., Engineering Marketing Manager for TI's Power Products Department. VMOS technology was selected for the first product introductions because it is among the most accessible process technologies.

Like all MOSFET devices, however, the TIP-F series will offer fast switching speeds, high input impedance, and freedom from secondary breakdown. ▪▪

Minicomputer tackles maxi loads with failsafe reliability

A 32-bit minicomputer from Formation Inc. (Mt. Laurel, NJ) stands apart in two distinct ways: Not only does the Model 4000 accept IBM 370 software—including DOS/VS, OS/VS1 and VM 370—but it also provides easy, failsafe reliability via redundant architecture and remote maintainability.

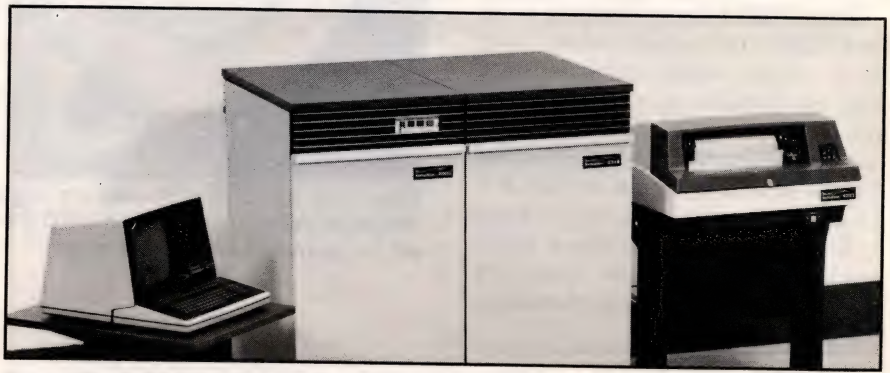
Within the 4000, a bit-slice CPU, error-correcting memory and I/O circuitry join with a Z80-based service processor, which monitors mini performance at initial program load, then continuously during operation. If trouble develops, the console operator lets the service processor communicate, via a built-in modem, directly with the manufacturer's facilities.

As a result, the problem may not only be diagnosed remotely but often cured simply by remotely modifying the microprogramming. For example, the CPU and disk controller, identical except for their programming (microcode), could be made to pinch-hit for each other. In fact, all major system components—CPU, memory, disk controller and service processor, could be made redundant, further reducing downtime.

All system components are connected to a high-speed multiplexed bus, 35 bits wide, which carries addresses, instructions and control signals—an architecture that greatly simplifies system expansion. Memory starts at 256 kbytes and can be increased to 4 Mbytes—and redundant units are added just as easily for CPU, service processor or any other subsystem.

The 4000 is also expected to approach the performance of IBM's 4331 for transaction processing, and also is aimed at applications, in number-crunching systems.

The basic system, consisting of a single CPU, 256 k of memory, a service processor, a console and one disk, will sell for $51,000 when production deliveries start in November. Test sites will, however, be operating by midsummer. ▪▪



Formation's 32-bit minicomputer, which has redundant subsystems, can be diagnosed and, in some cases, repaired from a remote site.

Max Schindler
Software Editor

Intel sees software modules, 32-bit μP in its future

About 70% of the total cost for software is incurred, according to recent estimates, after the product is delivered—during maintenance and debugging. Thus, the burden of system development is shifting from the hardware designer to the programmer. Advances in development systems and high-level languages should ease the programmer's task.

Yet, help is coming from a third direction also: modularized programs that are easily modified and strung together. Dave House, General Manager of Intel's Microprocessor and Peripherals Operation, and Alfred Hartmann, Project Manager for the company's Software and Systems Group, agree that this approach will help to restrain programming costs and problems, even while the programs continue to grow.

In future systems, transportable high-level languages will provide: a natural medium for describing a problem, larger building blocks for constructing a solution, data structures that reflect problem relationships and a common semantic base to close the communication gap.

Highly modularized programs will utilize design talent more effectively: While low-level personnel are developing modules, a few top-level individuals can concentrate on implementing the system design. With structured software, scheduling and costs become more predictable, because the problem is broken into smaller units; it is easier to keep track of the individual schedules for submodules. Finally, modularization reduces the chances that errors will spread throughout the entire system.

With these advantages in mind, Intel has developed its microsystem architecture to include small code modules, specified interfaces with module isolation, structured addressing and degrees of privilege. The current 8086 microprocessor employs a segmented memory space to hold relocatable program modules that can be drawn upon as needed. The user can change contexts swiftly and get flexible support for variable-length segments.

The next generation of microprocessors, as outlined by Dave House, will include an upwards extension of the 8086, as well as two even more powerful products. One of these may be a pseudo-32-bit processor with 16-bit external buses; the other will perform full 32-bit operations and may be directly programmable in a high-level language.

The CPU chips will manage and control address spaces beyond the current 1 Mbyte of the 8086 and offer such capabilities as memory protection and system control.

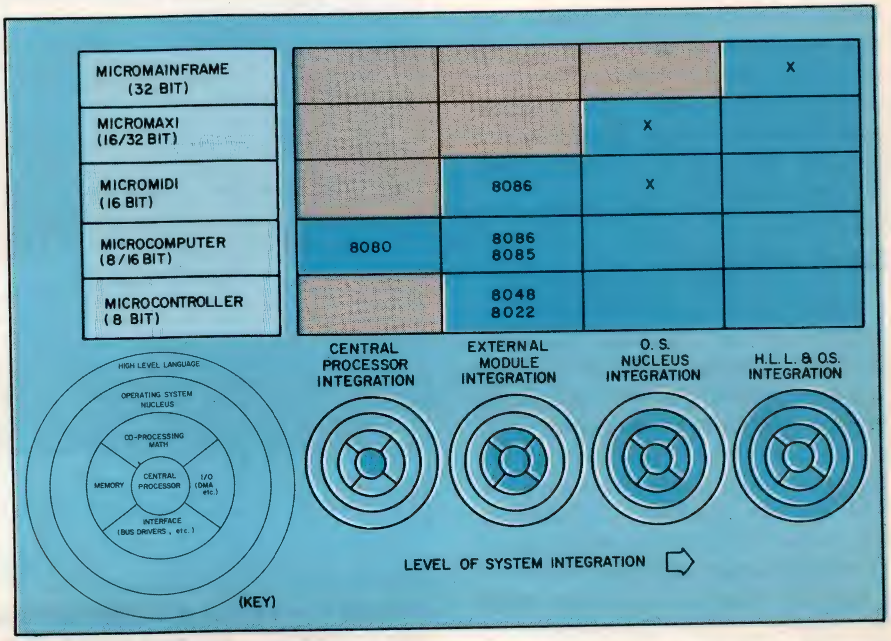
Some advanced microprocessors operate in two modes. In the system mode, the user has access to all the internal registers and can interfere with the system's operating system. In the normal mode, the processor runs the user's application program, and the user has no access to the operating system. The software operating system is usually stored in RAM after being loaded in from the disk.

However, future systems will take advantage of solid-state software—some of it placed on the same chip with the CPU. First, Intel will develop a kernel of commands (from their just-released RMX-86 operating system) to be integrated into silicon (ELECTRONIC DESIGN, March 15, 1980, p. 245). Eventually, separate operating-system kernels will provide different system capabilities.

As more and more software becomes integrated into systems, the term microprocessor will no longer serve; micromaxi and micromainframe are terms coined by Intel to indicate the software features that have been turned into hardware. Among the circuits that add tremendous computational and I/O capabilities to the CPU are the 8087 math circuit and the 8089 I/O processor. Eventually, these off-chip functions will be included on a single chip, along with the minimal software that ties it all together.

Fault-tolerant computing, transparent multiprocessing, distributed operating systems, advanced network architectures and families of programming languages will be entering the picture in the near future. Modularization of the software is merely the starting point. ■■

Dave Bursky
Semiconductors Editor



	CENTRAL PROCESSOR INTEGRATION	EXTERNAL MODULE INTEGRATION	O. S. NUCLEUS INTEGRATION	H. L. L. & O.S. INTEGRATION
MICROMAINFRAME (32 BIT)				X
MICROMAXI (16/32 BIT)			X	
MICROMIDI (16 BIT)		8086	X	
MICROCOMPUTER (8/16 BIT)	8080	8086 8085		
MICROCONTROLLER (8 BIT)		8048 8022		

Future Intel μPs will gain an on-chip operating system, and the 32-bit micromainframe will feature high-level language capability on-chip.

Progressive + successive approximation speeds ADC

Take the most widely used analog-to-digital converter architecture, successive approximation, add a few components to create a sense-and-clock-control circuit, and the result is progressive approximation (PA), a not-unknown technique that allows high-speed a/d converters to operate even faster. Sounds easy enough, except that PA has been difficult to implement. For one thing, the sense and clock circuits can become complex. For another, eliminating noise and providing proper trimming can become stumbling blocks.

In a new 12-bit hybrid a/d converter, the 4134 from Teledyne Philbrick (Dedham, MA), progressive approximation performs a conversion typically in 1.9 μs—vs 2.5 μs for a standard SAR converter.

While SAR ADCs are not the fastest converters—parallel types hold that honor—they are much faster than stairstep devices since they require only n comparisons for an n-bit conversion. Stairstep types make 2^n-1 comparisons for the same n-bit conversion.

An SAR converter makes comparisons one bit at a time, beginning with the most significant bit (MSB). The remaining bits, depending on the converter's resolution, are compared at a rate set by the clock frequency, until the conversion is complete. (The upper timing diagram shows the relationship between the most significant five bits and the clock in a typical 12-bit SAR converter.)

Speed obstacles

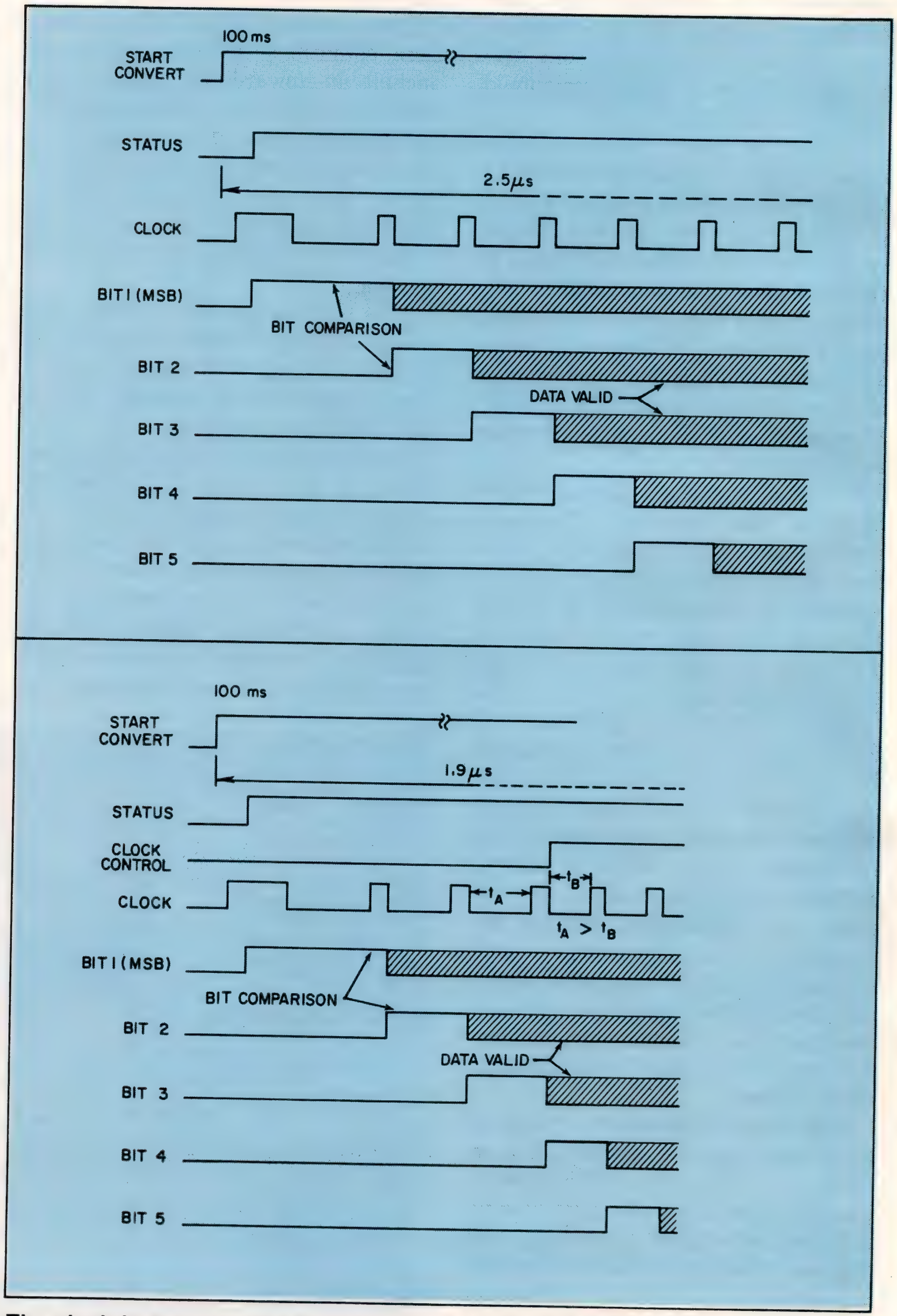
However, all SAR converters are plagued by two problems, one being that the maximum speed of the conversion cycle hinges on the settling times of the digital-to-analog converter, comparator and logic circuits. For the type of DAC used in parallel in SAR devices, response is slowed by the speed of the analog switches and parasitic reactances of the resistors.

But the biggest slowdown stems from the slew rate and settling time of the summing amplifier. In addition, the first two or three MSBs bear the brunt of the settling-time delays—they take longer to settle than the remaining bits.

One way around the MSB problem is to make the first two or three timing intervals longer than the rest, which allows the more significant bits extra time to settle. Another approach—and a more effective one—is the PA method used in the 4134.

Rather than increase the clock pulse for the more significant bits, the clock-and-sense circuit speeds up the clock rate for all bits after the third (see lower timing diagram). Since the

Gene Heftman
Field Bureau Editor



The clock in a successive-approximation ADC has a fixed timing interval (upper diagram), but with progressive approximation, the sense-and-clock circuit speeds up the clock for all bits after the third (lower diagram). As a result, conversion time drops from 2.5 μs to 1.9 μs.

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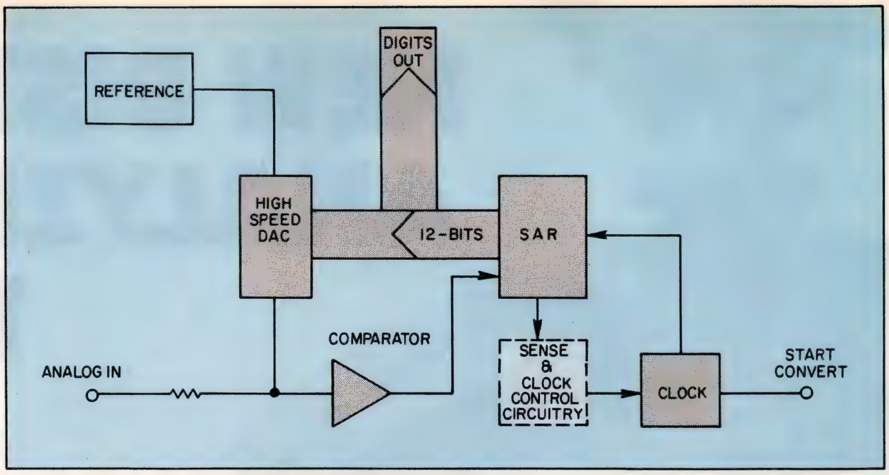
CIRCLE NUMBER 17

lower-order bits settle faster than the first three, they can be processed at an increased rate.

To maintain the 4134's high accuracy (±1/2 LSB), the MSB must settle to 0.012% of its final value. But the next most significant bit need only settle to 0.024% of its final value to hold 1/2-LSB accuracy. The lower the order of a bit, the less time required to let it settle to final value and still maintain the converter's accuracy.

At a predetermined time after the beginning of a conversion cycle (after the third bit comparison), the sense circuit is triggered and the clock circuit is set. The clock rate increases, and the internal DAC and comparator start settling faster. ■■



A successive-approximation ADC turns into a progressive-approximation converter with the addition of a sense-and-clock-control circuit. This speeds up conversion time without significantly increasing cost.

Mini-based development system builds software in easy pieces

A software development system called the Software Synthesizer combines a new high-level development language with a 16-bit minicomputer to cut software development time by factors of two or three. The custom Software Synthesis Language (SSL) permits programs to be developed from small, highly modularized program segments, much as systems are built from LSI building blocks. Not only that, but up to four programmers can simultaneously use the Software Synthesizer through remote CRT terminals.

Developed by Scientific Enterprises (Tigard, OR) and based on a Perkin-Elmer 16-bit Series Sixteen minicomputer, the system consists of the computer with 250 kbytes of error-correcting RAM, 38 Mbytes of Winchester-disk storage and a 13-Mbyte cartridge tape for disk backup and archival storage. Designed to offer transportability, the SSL will permit programs to move between such microcomputers as the MC68000, the Z8000, the Z80 and the MC6809, or such minicomputers or mainframes as the P-E Series Sixteen, the DEC PDP-11 and the IBM 360/370. Initially, the system will support the MC68000, but will soon be able to support any 8-bit or byte-addressable mini or micro through compiler-code generators currently being developed.

Quicker by four

Four programmers, aided by libraries of modularized routines for efficient programming, can work simultaneously on the same project, thus cutting the time for program development. Each CRT supplied with the system comes with an auxiliary RS-232-C port for downloading and communicating with local peripheral devices.

Each library routine consists of an interface section and an application-specific routine. The interface can describe all the capabilities implemented by the routine or "hide" those not required by the specific application, thus permitting the same routine to be used by several applications. Consequently, these "component" routines can be passed between programs.

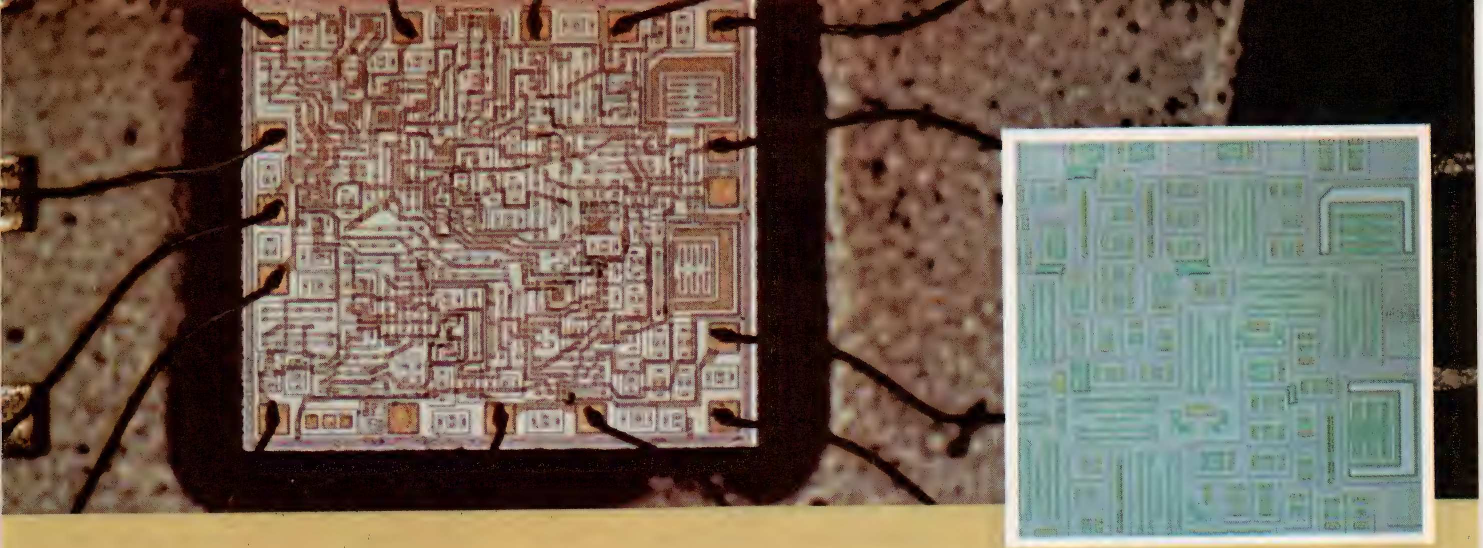
Basic operating software includes a text editor (VECO), a document formatter, some self-test diagnostics, and a multiuser operating system. The text editor contains 19 commands and includes features such as editing commands for characters, words, lines, or the entire text buffer; forward or backward search for character strings; repetitive commands; undo deletions; and exchange words or lines.

A formatter included in the system encourages the programmer to build both the software and its documentation at the same time. For example, the SSL compiler's parser is generated from the same text file used to generate the reference manual, thus guaranteeing agreement between the program and reference. In addition, the formatter can automatically add pages and footings, break text into numbered pages, fill or justify lines, or center and underline. It also handles variable spacing and proportional material with just a few explicit commands.

System self-test features perform extensive diagnostics on power-up and continuing tests of the hardware while the system operates. If a fault is detected in either hardware or software, fault indicators are turned on. When a memory fault is detected, the system's ECC memory permits operation to continue even when individual memory bits fail. The system also includes an automatic power-fail/restore capability with battery backup to retain data in memory for up to 20 minutes.

System options include a high-speed dot-matrix printer, remote in-circuit emulators and remote PROM programmers. Software options will include code generators for popular 8-bit and byte-addressable microprocessors and minicomputers, and a set of programming tools to automate the construction of compilers. The starting price for all this power, though, won't come cheap—a system including disk and tape storage and the four terminals will cost $83,000. ■■

Dave Bursky
Semiconductors Editor



Section of an Exar Master Chip before customizing. Note the individual circuit components already on-chip, but still unconnected. After the customer has designed circuit connections according to his system needs, Exar prepares a final mask and fabricates the custom chip, as shown in large photograph above.

This integrated circuit was manufactured to a custom design and delivered in a matter of weeks.

YOU CAN CUT DEVELOPMENT TIME UP TO NINE MONTHS ON BIPOLAR AND I²L CUSTOM CHIPS... WHILE YOU SLICE COSTS TO THE BONE... THROUGH THE UNIQUE "SEMI-CUSTOM DESIGN PROGRAM" FROM EXAR INTEGRATED SYSTEMS. Compared to traditional development times for custom ICs, which frequently exceed one year, and tooling costs which can be five to ten times greater, this new concept allows custom chips to be justified economically at far smaller quantities than previously thought practical.

How the semi-custom idea works.

Exar's standardized circuits contain undedicated active and passive components such as transistors, resistors, logic gates, etc., fabricated onto the chip, but left unconnected. You choose how to interconnect these components to create your own custom circuit. The actual interconnection process is simple, requiring only one to three layers of tooling. As a result, development time compresses drastically, becomes far less expensive and virtually risk free.

Choose from eight different chips.

Five of the standard semicustom chips are bipolar, and are best suited for linear designs. Some (XR-A100, XR-C100, XR-F100) feature high current NPN output transistors, making them suitable for drive circuits. The others (XR-B100, XR-D100), more appropriate for signal amplification or control circuits, contain only small signal, low current transistors. All, however, present the designer a wide variety of NPN and PNP transistors, Schottky diodes, various resistors and ample bonding pads.

Exar's three I²L digital chips (XR-300, XR-400, XR-500) contain high density I²L logic arrays and bipolar interface circuitry. Outwardly they look and perform like a bipolar LSI chip, readily interfacing with TTL or MOS level signals. This feature, incidentally, makes it very convenient to retrofit I²L LSI designs into existing MOS or TTL logic systems.

And Exar has in development additional semi-custom chips offering even greater applications flexibility.

If you decide to modify your design.

Even after evaluation of initial design prototypes, if you see a need to modify the custom chip, a new design iteration usually takes less time than the original development cycle. And typical costs of additional design cycles are proportionately less than the original prototype development cost.

What about second sources?

This is one of our most asked questions. In response, Exar has made alternate-source agreements with other IC manufacturers, so you can specify and order custom circuits with confidence.

Testing, testing.

After prototype acceptance of semi-custom devices, Exar will develop software and fixtures for fully testing all production ICs. Production devices receive 100% electrical testing, and are screened to agreed-upon Acceptable Quality Level (AQL) standards. Charges for this test engineering are nominal, and vary depending on the complexity of the tests.

Semi-custom to full custom. For when the numbers get big.

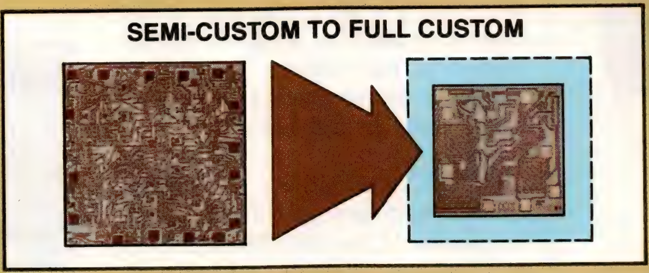
Because Exar manufactures its own wafers, it can grow with your needs. As your product matures we can convert your semi-custom chip into a customized IC. Consider the advantages: You get the quick, inexpensive turnaround of semi-custom chips, providing prototypes and intial production units; then when your design has proven itself and your market has developed, the subsequent full custom product provides further cost savings at high volume production... often with a significant improvement in product performance!

Design kits make it simple.

Exar provides linear and digital design kits, including circuit components for breadboarding, comprehensive design manuals and layout worksheets corresponding to Exar's master chips. These, as well as technical assistance when you need it, will speed and simplify your preliminary steps toward custom IC design.

Learn the economics and advantages of semi-custom.

Exar's entire semi-custom story is detailed in a 40-page data book, "Semi-Custom IC Design Programs." For your copy, write on company letterhead to your nearest Exar representative or to Exar, 750 Palomar Ave., Sunnyvale, CA 94086.



Exar can convert your semi-custom chip to a custom IC, reducing chip size, saving money, and often providing added performance benefits.

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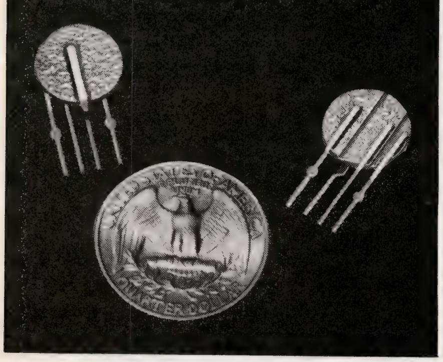
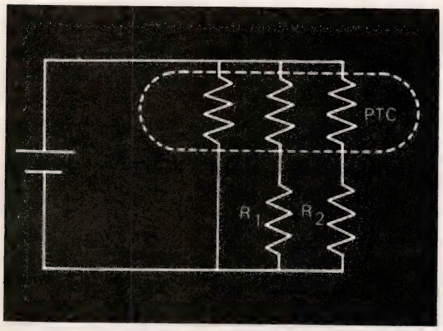
Keystone

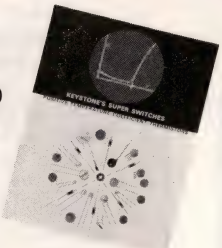
PTC THERMISTORS SPEED UP TIME DELAYS



The circuit diagramed below illustrates a single three-section PTC thermistor used as a two-stage time delay. The third section acts as an auxiliary heater supplementing the joule heat generated in the other sections. As a result, the device creates significantly shorter time delays than would be possible without altering other circuit parameters.



Send for Bulletin P-780



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CIRCLE NUMBER 19

Flat-panel displays getting help from many technologies

While the TV picture on a wall remains a long-awaited goal, experimental advances in several flat-panel-matrix technologies are bringing it closer to reality. Liquid-crystal electroluminescence, plasma, electrochromic, magnetic-particle and dye-foil technologies are all fueling the race to produce a practical successor to the long-necked CRT.

Progress in all these flat-panel sectors will be reported and described at this year's International Seminar and Symposium to be held by the Society for Information Display in San Diego, CA.

In the liquid-crystal sector, multiplexing techniques being increasingly applied to TV displays are bringing out more levels of gray shading. Using the principle of electrically controlled birefringence, the LETI/Commission on Atomic Energy (Grenoble, France) has developed a 256 × 256 TV panel having 32 gray levels.

The technology can also be applied to colored displays, and LETI representatives will discuss the operating principles of a 264 × 272 display. In addition, improving the uniform brightness of liquid-crystal flat panels will be considered by a team of specialists from Hitachi Research Laboratory (Ibara-i-ken, Japan).

Meanwhile, electroluminescence (EL) technology is brightening the flat-panel picture at the Rockwell Electronics Research Center (Thousand Oaks, CA), where plans are underway for a matchbox-size TV display system using thin-film (25 × 38-mm) display-area ELs and hybrid drivers. The display area will contain 515 × 680 elements and provide a resolution of 500 lines/in. In addition, Rockwell has developed a high-density evaporation method to interconnect an EL video display to a hybrid electronics substrate.

Another alternative, ac plasma panels, is getting support from at least two places. At the IBM Research Center (Yorktown Heights, NY), experiments with new material combinations have produced a blue panel. A gas mixture of mercury-seeded argon produces the blue luminance.

On the other hand, Texas Instruments (Dallas, TX) is doing something about the high cost required to drive such displays. The company promises a method that not only reduces the drive-electronics cost but maintains high-levels panel reliability as well.

Electrochromic displays, also burdened by practicality hassles, are the focus of IBM Laboratories (Winchester, England), which reports a practical 4096-pel display. The device is fully integrated on a silicon chip that contains the necessary drive and addressing electronics.

Another attempt at bringing a fresh look to flat-panel displays is the magnetic-particle approach under development at Magnavox (Fort Wayne, IN). The company reports progress in two areas—encapsulation of the magnetic particles and fabrication of the addressing matrix and memory.

Over at Bendix Research Laboratories, (Southfield, MI) a dye-foil display is being heralded as a challenger to liquid-crystal flat-panels. Reportedly offering better performance and a wider temperature range in the lab, the dye-foil is a passive panel that operates by electrostatically deflecting a metallic foil in a dye-filled chamber.

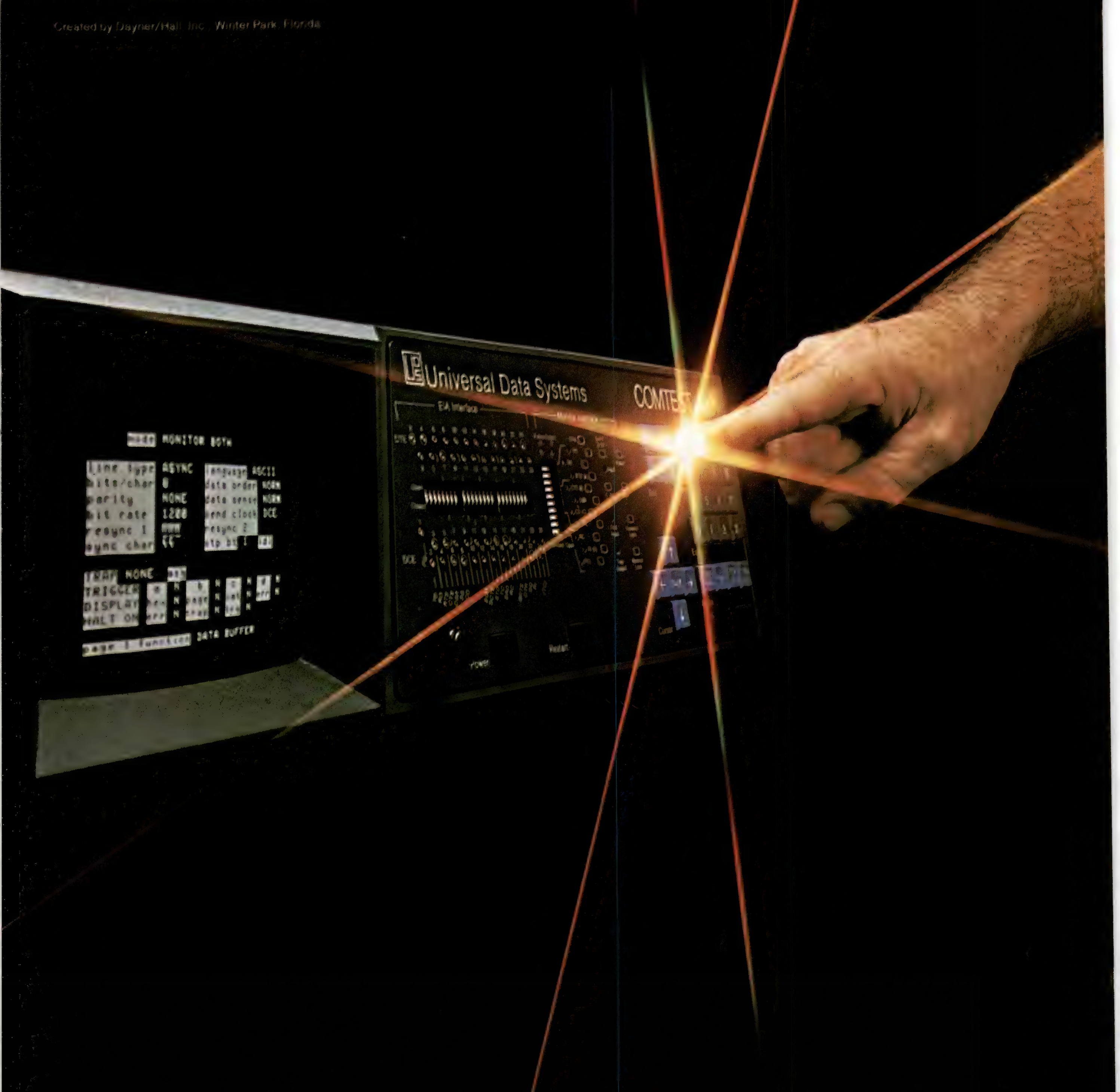
Cathodeluminescence is being applied to a large-area TV display by RCA Laboratories (Princeton, NJ). In the system, electron-beam guides confine and distribute video-modulated current from a localized electron source to all display elements. ■■

Gene Heftman
Field Bureau Editor

Want to go?

The International Seminar and Symposium of the Society for Information Display will be held at the Town and Country Hotel, San Diego, CA, April 28 through May 2. For information on the technical program and special seminars, contact Lewis Winner, 301 Almeria, P.O. Box 343788, Coral Gables, FL 33134; (305) 446-8193.

Created by Dayner/Hall, Inc., Winter Park, Florida



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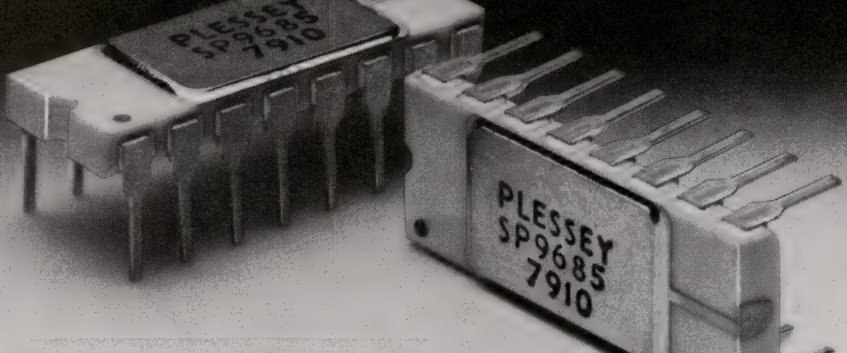

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CIRCLE NUMBER 142

P236

Electronic Design
INTERNATIONAL

March 29, 1980

S/d-converter modules mount 0.5 in. apart

μP-based cartridge drive—a versatile interfacer

Pocket-sized counter measures to 550 MHz

Low-power inverters synthesize sine waves

Integrated circuits
Semiconductors/Electron tubes
Components/Assemblies
Materials

NEWS FROM PHILIPS

BOTTOM ENTRY F095 CONNECTORS

The well-known F095 series of connectors has been further extended by a range of bottom entry female versions. The new connectors enable low-cost sandwich construction of printed circuit boards where the connections can be made from either the top or bottom of the connector.

Short tin-plated terminations are provided and these are bent over and soldered on the rear side of the p.c. board. Connection to an adjacent p.c. board is made using an F095 male header which is fixed to that board. The pins of the male header can enter the connector from either side depending on the method of mounting.

Use of the new versions enables two or more p.c. boards in a rack, for example, to be interconnected without problems of orientation due to component mounting, or soldering of connections. The latter can be accomplished using an automated process because the new connectors can be mounted on the component side of the p.c. board.

The new bottom entry types have black thermoplastic polyester bodies and phosphor bronze springs. The contacts are 1,5 micron rolled gold on 1 micron nickel. Single row connectors up to 32 terminations (1 x 32) and double row connectors up to 10 terminations (2 x 10) are now available.

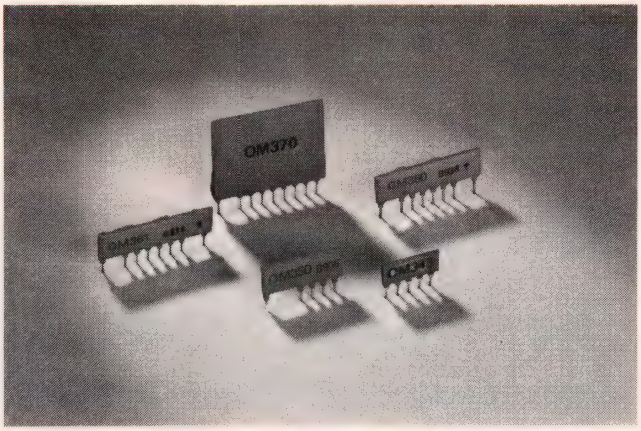
CIRCLE NUMBER 800

E.H.T. RECTIFIER DIODE

Our BY509 e.h.t. rectifier diode in a glass envelope is designed for encapsulation in diode-split transformers, triplers and other e.h.t. devices. As the successor to the BY409 in plastic, the BY509 features glass passivated aluminium alloyed crystals which enable a higher working temperature of 120 °C to be achieved.

The combination of a repetitive peak reverse voltage of 12,5 kV maximum, an average forward current of 4 mA, a reverse recovery time of typically 0,2 µs, and the high working temperature of 120 °C, make the BY509 an excellent choice of e.h.t. diode.

CIRCLE NUMBER 802



12 V WBA STANDARD RANGE EXTENDED

With the addition of the OM345 and OM370, our standard range of 12 V hybrid integrated circuit VHF/UHF wideband amplifiers is now extended to include five types. The OM345 is a single stage amplifier with a transducer gain of 12 dB and an output voltage at 470 MHz and −60 dB intermodulation distortion (DIN 45004, 3-tone) of 99 dBµV. It has a flatness of frequency response of 1 dB and a noise figure of 5,5 dB. The OM345 is intended for aerial amplifiers in car radios, caravans, or RATV and MATV applications.

The OM370 is a three stage wideband amplifier with a transducer gain of 28 dB and an output voltage measured under similar conditions to the OM345 of 114 dBµV. The flatness of the frequency response is also 1 dB and the noise figure is 7 dB. The OM370 is intended for masthead booster amplifiers in MATV and CATV systems and as a general purpose amplifier in VHF and UHF applications. It is the 12 V version of the OM337 24 V version, but with improved performance particularly on noise.

The 12 V standard range also includes the OM350 with 18 dB gain and 100 dBµV output voltage, the OM360 with 23 dB gain and 107 dBµV output voltage, and the OM361 with 28 dB gain and 107 dBµV output voltage. All values given are typical values.

CIRCLE NUMBER 801

THIRD GENERATION PHOTO-COUPLERS

Combining the advantages of two generations of photocouplers, our CNX35 and CNX36 have high current transfer ratios, high insulation and low saturation voltages. Composed of an infrared gallium arsenide diode and a silicon n-p-n photo-transistor with an accessible base, the new types are of planar construction using a single leadframe. Their 6-pin dual-in-line SOT-90 encapsulation makes them easy to use in circuits requiring optical isolation at high voltages.

The diode has a continuous reverse voltage rating of 3 V maximum, and a forward current of 100 mA maximum. The V_{CEO} of the transistor is 30 V maximum. The CNX35 and CNX36 have current transfer ratios greater than 0,4 and 0,8 respectively.

The two types have a dark current (I_{CEW}) of 200 nA maximum at 1,5 kV d.c. working voltage and V_{CC} of 10 V. Their isolation voltages are 3 kV r.m.s. and 4,4 kV d.c.

CIRCLE NUMBER 803

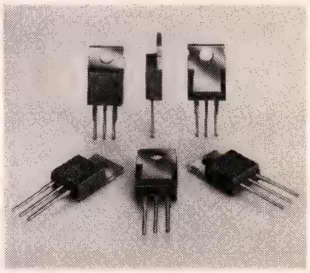
DARLINGTON POWER TRANSISTORS

The addition of 50 W and 125 W versions to our range of Darlington power transistors further extends the application of these well-known TO-220 encapsulated devices.

The new types are available in four different voltage versions in both p-n-p and n-p-n construction. The 50 W p-n-p types, designated BDT60/A/B/C have V_{CEO} ratings of 60 V, 80 V, 100 V and 120 V maximum, respectively. Peak collector current is 6 A maximum. The n-p-n types are designated BDT61/A/B/C and have similar ratings.

The 125 W versions, BDT64/A/B/C for p-n-p types, and BDT65/A/B/C for the n-p-n types, are available with similar voltage ratings to the 50 W versions. Peak collector current is now 20 A maximum.

In addition to these new types, the Darlington range includes the 62,5 W types BD645/646 and the 90 W types BDT62/63. All transistors in this range feature eutectic-bonding of the chip to the lead frame, passivation of the chip surface, ultrasonic unimetal bonding of chip connections and an integral one-piece copper heatsink. All this adds up to high performance and reliability.



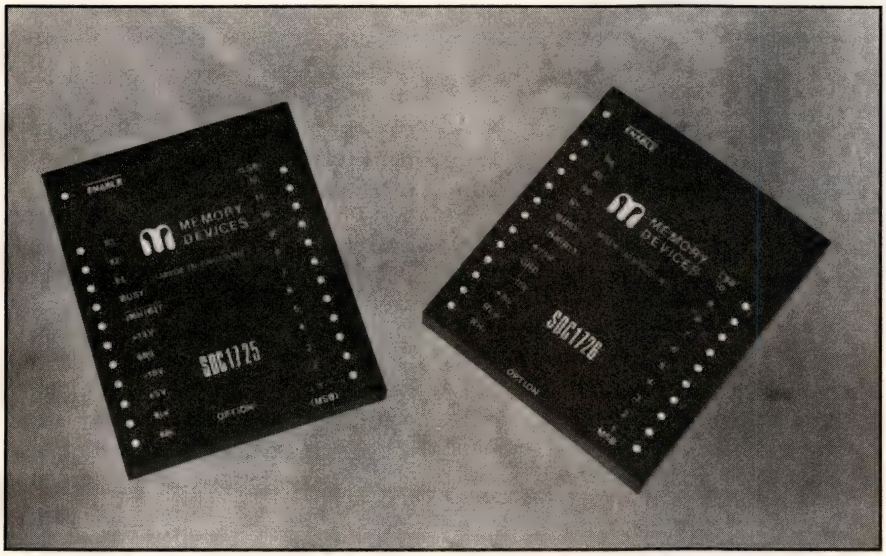
CIRCLE NUMBER 804

Philips Industries
Electronic Components and
Materials Division
Eindhoven – The Netherlands

PHILIPS
Components
and Materials

PHILIPS

Synchro-to-digital converter modules feature low profile and latched outputs



These modular 10 and 12-bit synchro-to-digital converters boast a low profile of 0.35 in. and three-state latched outputs as well.

Memory Devices, Ltd., Central Ave., E. Molessey, Surrey KT8 OSN, England. (01) 941-1066. Telex: 929962.

The SDC1725 and SDC1726 synchro-to-digital converters will mount on printed-circuit boards only one-half inch apart. The SDC 1725 provides 12-bit s/d conversion and the SDC 1726 provides 10-bit s/d conversion. With a height of only 0.35 in. (8.9 mm), each of these modules from Memory Devices has a lower profile than any other modular s/d converter.

Exhibited under the banner of Analog Devices (Memory Devices' parent company), the new s/d converters are among a wide range of data-conversion components being shown at this month's Salon International des Composants Electroniques in Paris.

Because the s/d converters feature internal three-state latched outputs, they may be multiplexed onto a single data bus. The three-state outputs also simplify interfacing with microcomputers and other data-processing equipment and facilitate the transfer of data without errors.

Data are transferred from the converter without opening the internal control loop. Instead, the transfer is controlled by Inhibit and Enable commands, avoiding the problems of slow recovery.

The s/d converters have the same basic design as earlier modules in the SDC1700 series. This design employs a Type-2 servo loop and allows continuous tracking even during data transfer. Like the earlier SDC1700, the 1725 and 1726 can accept either three-wire synchro or four-wire resolver signals, depending on the option chosen. Internal transformers accept 60-Hz, 400-Hz or 2.6-kHz reference signals. Line-to-line signal voltages can be either 26 or 115 V rms, with corresponding resistive-input impedances of 26 or 200 kΩ. To accommodate a variety of applications, the signal and reference voltages can be scaled with external resistors—a change in applications requirements, then, does not require a change of modules.

Even the units that contain 60-Hz transformers keep a low profile. Normally, 60-Hz transformers are bulky, and modules from other manufacturers have often omitted the transformers—which must then be mounted externally. Memory Devices, however, developed special microtransformers, which fit into a small package without sacrificing performance.

All versions of the SDC1725 have a maximum error of only ±3.2 arc-min. ±1 LSB. For the SDC1726, the accuracy is ±22 arc-min. Both units provide fast tracking without velocity lag. Depending on the signal and reference frequency, the guaranteed tracking rate is 5 rev/s for a 60-Hz frequency; 36 rev/s for 400 Hz; and 50 rev/s for 2600 Hz.

Standard versions of the 1725 and 1726 operate over a temperature range of 0 to 70 C. However, versions are available for operation over an extended range of −55 to +105 C. The storage temperature range is −55 to +125 C for both the standard and extended-range versions.

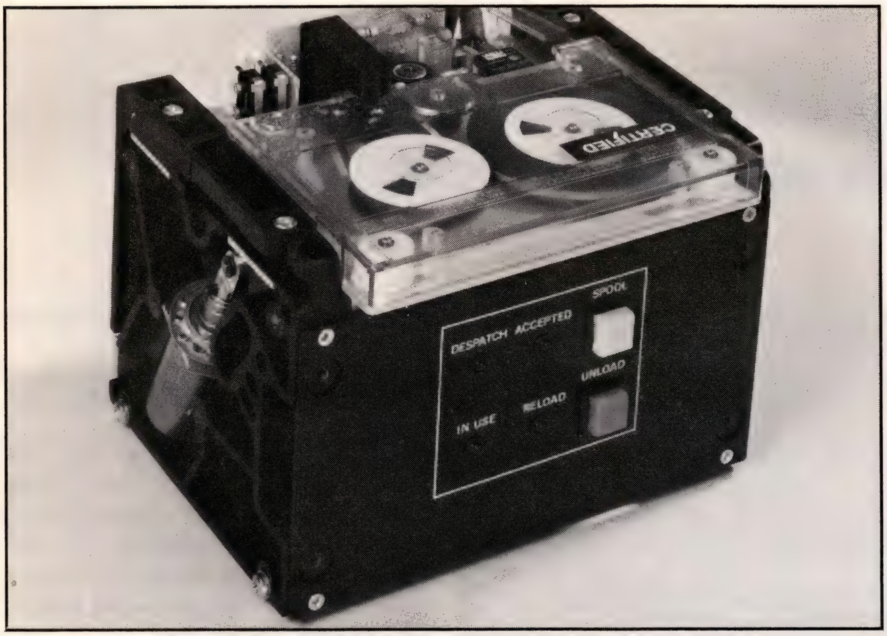
In addition to the ac reference supply, the converters require dc supplies of ±15 V and +5 V. Total power dissipation is 1.35 W: current requirements are 25 mA for each of the 15-V lines and 120 mA for the 5-V line.

The exact frequency of the signal and reference signals is not critical. A 60-Hz converter can be used from 50 Hz to 400 Hz, and a 400-Hz converter can be used from 400 Hz to 2600 Hz. However, the units retain their specified dynamic characteristics—tracking rate, for example, does not automatically increase with frequency.

The modules weigh 3.3 oz (93 g) and have dimensions of 3.125 × 2.625 × 0.35 in. (79.4 × 66.7 × 8.9 mm).

CIRCLE NO. 501

μP-based cartridge drive emulates and interfaces



Feedback Data Ltd., Bell Lane, Uckfield, Sussex TN22 1PT, England. Uckfield (0825) 4222. Telex: 95607.

Thanks to a built-in microprocessor, the TCD330 tape-cartridge drive is versatile enough not only to emulate other cartridge drives, but also to interface with various data-processing systems. Made by Feedback Data, the 3-kg, 140 × 190 × 200-mm TCD330 was designed to meet the company's own varied data-storage needs and is now available to OEMs.

With the μP-based design, various configurations can be formed to match customers' existing circuits—particularly when the unit replaces an older cartridge-drive unit. Initially, however, the TCD330 is being offered with a standard TTL-compatible interface.

The cartridge drive meets the requirements of ECMA and ISO data-recording standards when used with standard DC300 3M-type cartridges. More important, however, it is designed to drive cartridges that, because of prolonged usage, may no longer conform to the standards.

Precision-machined mountings for all assemblies eliminate the need for mechanical adjustments and simplify the interchange of subassemblies. A cartridge-locking mechanism allows the drive unit to be mounted and operated in a vertical or horizontal plane.

A four-track, dual-gap recording head provides phase-encoded recording at 1600 bits/in. Operational tape speed is 30 in./s; searching, spooling and rewinds take 90 in./s. A servo system holds the operational speed within ±5% for rapid speed perturbations and ±2% over the long term. The start/stop time is 25 ms at 30 in./s.

In OEM quantities, the tape-cartridge drive starts at £595.

CIRCLE NO. 502

Pocket instrument counts frequencies to 550 MHz

Continental Specialties Corp., Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ, England. (0799) 21682. TWX: 817477.

About the size of a pocket calculator and powered by rechargeable batteries, the MAX-550 frequency counter from Continental Specialties weighs just 230 g (8 oz) and measures just 76 × 152 × 83 mm (2 × 6 × 1.5 in.)—yet its measuring range is guaranteed from 1 kHz to 550 MHz.

A six-digit display employs bright and legible LED readouts. An internal crystal-controlled time base gives an accuracy of three parts in 10^6 for signal levels down to 250 mV.

Simple to operate, the instrument is equally suited to laboratory or field measurements. There is no need to switch or adjust for polarity, slope, trigger level or input level. Most controls are automatic, with automatic lead-zero blanking also incorporated.

MAX•550
531.692
550 MHz FREQUENCY COUNTER
OFF
ON
continental specialties corporation

Typical applications include audio, video and rf-circuit testing, checking clock frequencies for digital systems, and field tests on marine, ultrasonic or telecommunications equipment.

The internal rechargeable batteries allow continuous use for over 2 hours or intermittent use for 8 hours. The instrument can also be operated using an external dc supply—such as an automobile battery—that delivers a voltage from 7.2 to 12 V dc.

The MAX-550 is supported by a full range of accessories, including a miniature antenna for direct radio reception, an input cable, a carrying case, ac recharging units, and an adapter for use with a car battery.

Without the optional accessories, the frequency counter costs just £93 (plus VAT).

CIRCLE NO. 503

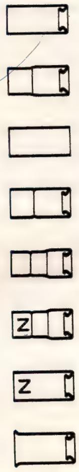
The Carby Corporation

203/274-6741

768 STRAITS TURNPIKE, WATERTOWN, CONN, 06795

PRECISION MADE **TUBES** CONNECTOR COMPONENTS

TYPES OF CONNECTOR COMPONENTS *



- REGULAR HOOD
- HOOD WITH RECONE
- REGULAR SLEEVE
- HOOD WITH CREASE
- HOOD WITH RECONE AND CREASE
- HOOD WITH RECONE, CREASE, AND MARKING
- HOOD WITH MARKING
- HOOD WITH FLARED END

* In the jargon of various industries these connector components are known also as contacts, socket contacts, hoods, sleeves, tubes, and shrouds. But in every language Carby components are accurate, reliable, miniature and sub-miniature performers. They're shown at right in dimension . . . at 200% magnification.

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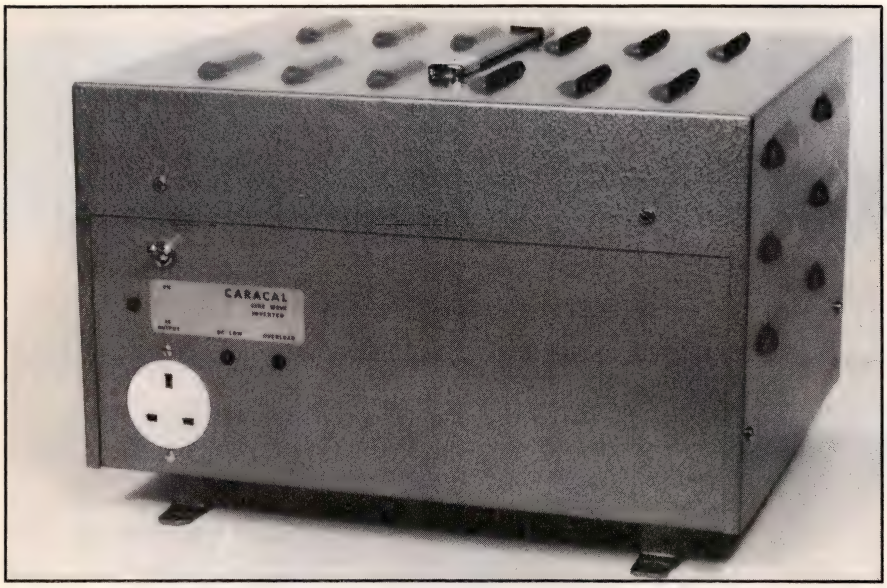
CIRCLE NUMBER 150

Low-power inverters deliver synthesized sine waves



Caracal Engineering, 42-44 Shortmead St., Biggleswade, Bedfordshire, England. (0767) 81361.

At a competitive price, synthesized-waveform power inverters—and their accurate sine-wave output—become practical for low-power systems. The light-weight inverters from Caracal Engineering have low-power ratings from 120 VA to 1 kVA.

Previously, inverters with waveform synthesis were restricted to high-power systems where energy savings justified their cost. Low-power systems had to rely on the less accurate output of inverters that used tuned-transformer techniques.

The new synthesized-waveform inverters provide 50-Hz or 60-Hz power at 220-240 V ac or 110-120 V ac. They operate from 12 or 24-V batteries and feature high efficiencies with either full or partial loads. Both the output voltage and the frequency are very stable under all load conditions. Distortion of the output sine wave is only 5%, and the frequency is stable to within ±0.3 Hz.

Full protection is provided against overloads, short-circuits and reversed input. The inverters are built with rugged steel cases for either fixed or mobile operation.

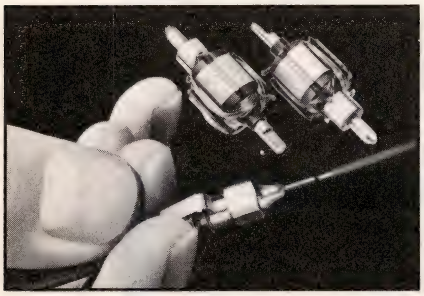
The unit with the lowest power rating (120 VA) weighs 10 kg and is 255 × 282 × 265 mm. The highest power rating (1 kVA) comes from a 255 × 560 × 360-mm unit weighing 32 kg.

Battery protection is provided by a low-voltage warning and automatic cut-out. Optional automatic standby operation ensures the continuity of ac power to important loads. Soft starting eliminates surge currents into the load or from the battery.

Over the rated battery voltage ranges of 11 to 14 V dc or 22 to 28 V dc, the output voltage is stable to within ±4%. This stability is maintained for any load up to full load and with load power factors from 0.7 lagging to 0.7 leading. With no load, the input current is nominally 12% of the full-load input current. All inverters in the new Caracal series operate from −10 to +40 °C.

CIRCLE NO. 504

Flame generator uses water and electricity



Spirig Industries, P.O. Box 160, CH8640 Rapperswil, Switzerland. (055) 274403. Telex: 75400.

Precision welding, brazing and soldering of miniature parts is simplified by using a WaterWelder gas generator. The unit produces the necessary gases by electrolysis of water. Flame size is controlled electronically. There are no bottles, no valves to mix gas ratios, and no burning tips. You just switch on the WaterWelder and use it immediately. An important application is the welding of thermocouple junctions, which use metals with high melting temperatures, such as platinum.

CIRCLE NO. 505

Interactive software draws in perspective

Tektronix U.K. Ltd., Beaverton House, P.O. Box 69, Harpenden, Hertfordshire, England. Harpenden 63141. Telex: 25559.

The Autoprod interactive program, for use on the Tektronix 4081 graphic display, generates drawings of three-dimensional objects and automatically removes the hidden lines. Developed by Autoprod Computer Graphics in the U.K., the software eliminates the time-consuming manual effort of generating perspective drawings. The software also allows up to three sectioning planes to be applied to a design.

CIRCLE NO. 506

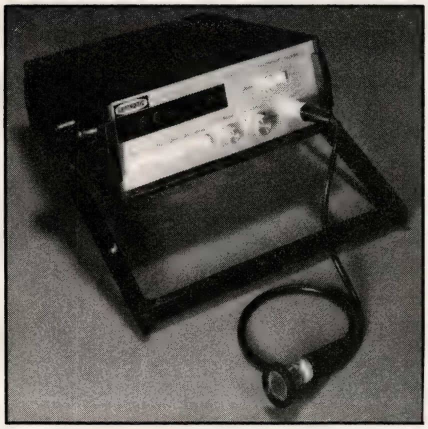
Versatile low-cost IC is wideband amplifier

Plessey Semiconductors Ltd., Cheney Manor, Swindon, Wiltshire SN2 2QW, England. (0793) 36251. Telex: 449637.

A versatile amplifier IC, the SL560CDP, has a bandwidth of 300 MHz and allows low-noise operation. Use of automatic test equipment and an 8-pin plastic package allows Plessey to produce the IC at low cost for volume orders. The amplifier is current and gain programmable. A suitable choice of external resistors varies the gain from 10 to 40 dB and the current consumption from 200 μA to 40 mA. The output is 10 dB into 50Ω. The SL560CDP is attractive for consumer equipment because of its low cost, and for professional audio equipment because of its 50-Ω impedance.

CIRCLE NO. 507

Bench instrument works as photometer or radiometer



Laser-Optronic, Avenue de Broqueville 222, Boite 6, B-1200 Brussels, Belgium. (02)711-2166. Telex: 61439.

The Model-210 photometer/radiometer is a laboratory standard bench instrument. It employs a combination of analog and digital techniques to allow fast and accurate measurements and a flexible choice of displayed units. Direct readings in all standard photometric and radio-metric units are displayed as a 3-1/2 digit decimal with single-digit signed exponent. Readings can be scaled by powers of ten. The instrument has a sensitivity of 10^{-12} W, 10^{-5} Lux or 10^{-13} A. Range selection is both manual and automatic over eight decades of power readings and manual over four energy decades. Thus, both continuous and pulsed sources can be measured.

CIRCLE NO. 508

Microcomputer accepts "piggy-back" memories

GEC Semiconductors Ltd., East Lane, Wembley, Middlesex HA9 7PP, England.

An improved version of the Intel iSBC-86/12 16-bit single-board microcomputer has been designed to accept a number of new "piggy-back" modules. These increase the total memory to 96 kbytes. Known as the iSBC-86/12A, the new version provides advantages in operating speed, power consumption and versatility. Two compatible memory modules are the 32 kbyte "Multimodule" RAM (iSBC-300) and the "Multicodule" EPROM (iSBC-340), which expands the microcomputer's on-board EPROM capacity from 16 to 32 kbytes. Hardware is provided with the "piggy-back" modules for mounting them onto the iSBC 86/12A motherboard and connecting them to the required power supply. With both expansion modules in place, the iSBC-86/12A occupies only one card slot in a Multibus card cage, provided it is an end slot.

CIRCLE NO. 509

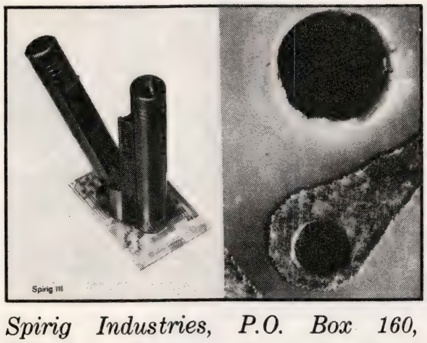
Tape-cartridge unit provides back-up for ATE

Gould Instruments Div., Roebuck Rd., Hainault, Essex 1G6 3UE, England. (01) 500-1000. Telex: 263785.

A magnetic tape-cartridge unit, the A5200, provides a nonvolatile memory back-up for the Gould Advance ACT series of automatic continuity testers. The cartridge unit connects to the tester via an IEEE-488 bus interface. It provides users with a simple means of storing a permanent library of test patterns of known good units to allow comparison testing. Standard 3M cartridges are used.

CIRCLE NO. 510

Pocket microscopes have built-in illumination



Spirig Industries, P.O. Box 160, CH-8640 Rapperswil, Switzerland. (055) 274403. Telex: 75400.

Powerful, pocket-sized microscopes have built-in illumination. Power is provided by penlight batteries. Quality glass lenses and a focusing ring give clear and sharp pictures. Different versions have 30× and 100× magnification. The microscopes are especially useful to quality-control inspectors and engineers working with PC boards.

CIRCLE NO. 511

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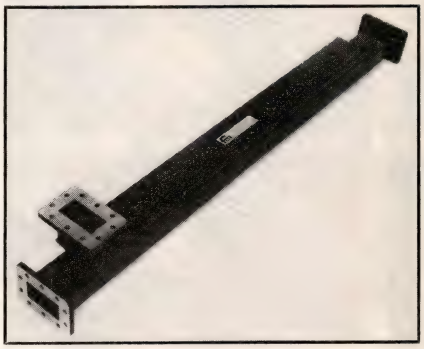

Flann Microwave Instruments Ltd., Dunmere Rd., Bodmin, Cornwall PL31 2QL, England. Bodmin (0208) 3161. Telex: 45456.

A series of multi-hole directional couplers provides high directivity for such applications as reflectometer systems. Standard versions have coupling values of 3, 10 and 20 dB. Versions with other coupling values, such as 6, 30 and 40 dB, can be supplied. A representative unit, Model 11A/13-2B, has a 10-dB coupling value and a directivity of greater than 46 dB over the frequency range of 3.3 to 4.9 GHz.

CIRCLE NO. 512

Compact coax connector fits high density systems

Sealectro Ltd., Walton Rd., Farlington, Portsmouth, Hampshire, England. Cosham 73211. Telex: 86142.

Intended for high density bulkhead connections, the type 51-427-3196 bulkhead jack has an overall length of only 0.359 in. Bulkhead attachment is achieved with a threaded section and a 0.187-in. hexagonal fixing nut. The connector can be crimped to standard RG-196/U or RG-178/U miniature coaxial cable and works at frequencies up to 12 GHz. The mating end provides positive engagement with all snap-on plugs in Sealectro's Nanohex series. A telescoping interface design ensures error-free repeat mating without risk of damage to contacts or dielectric.

CIRCLE NO. 513

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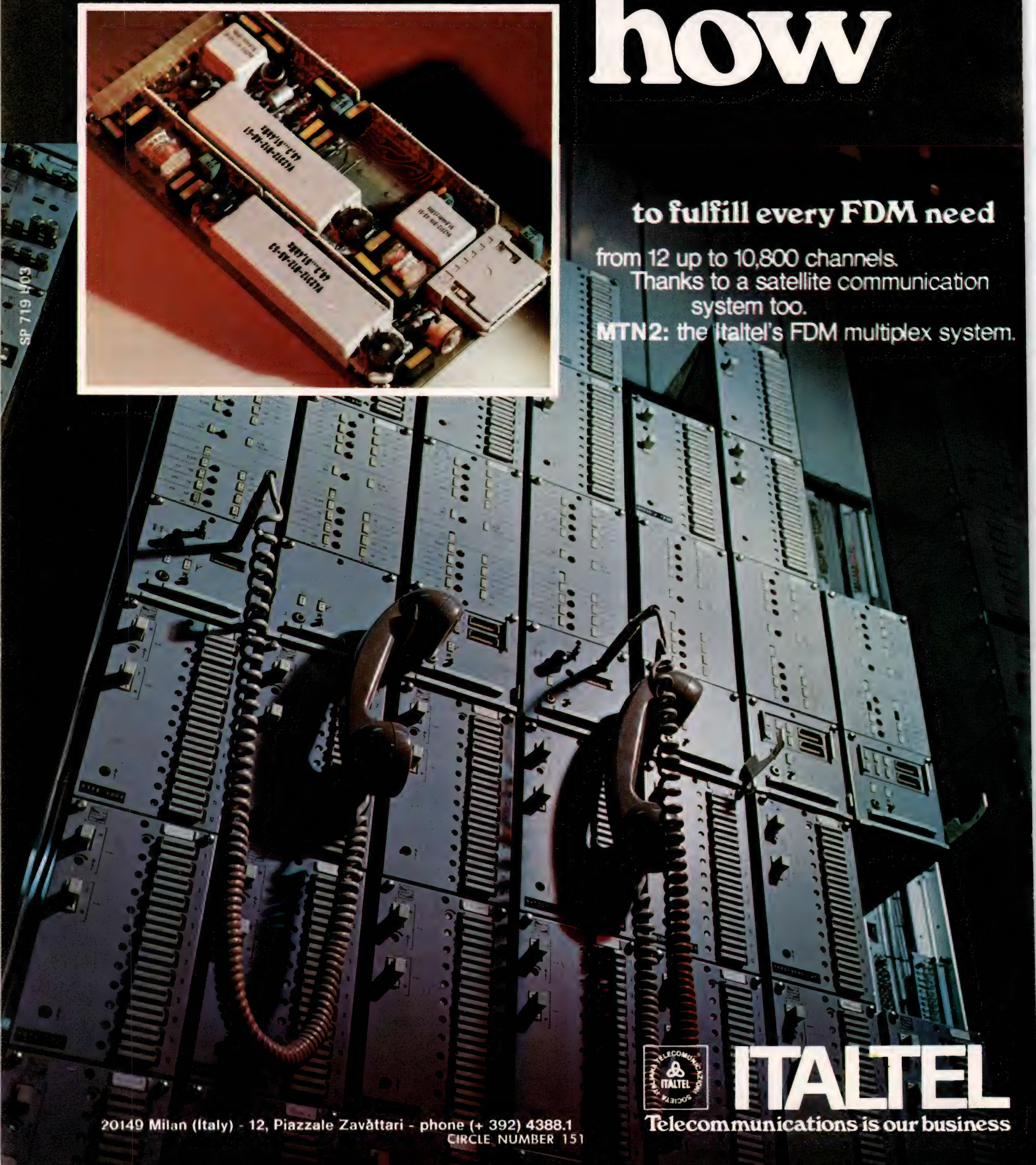

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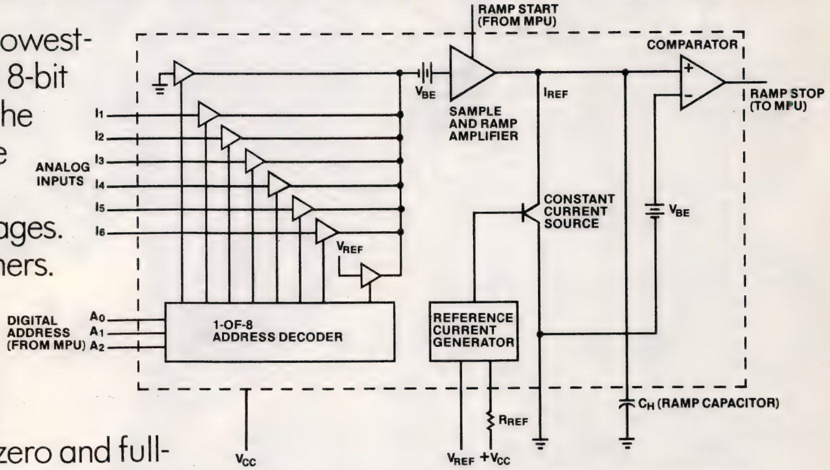

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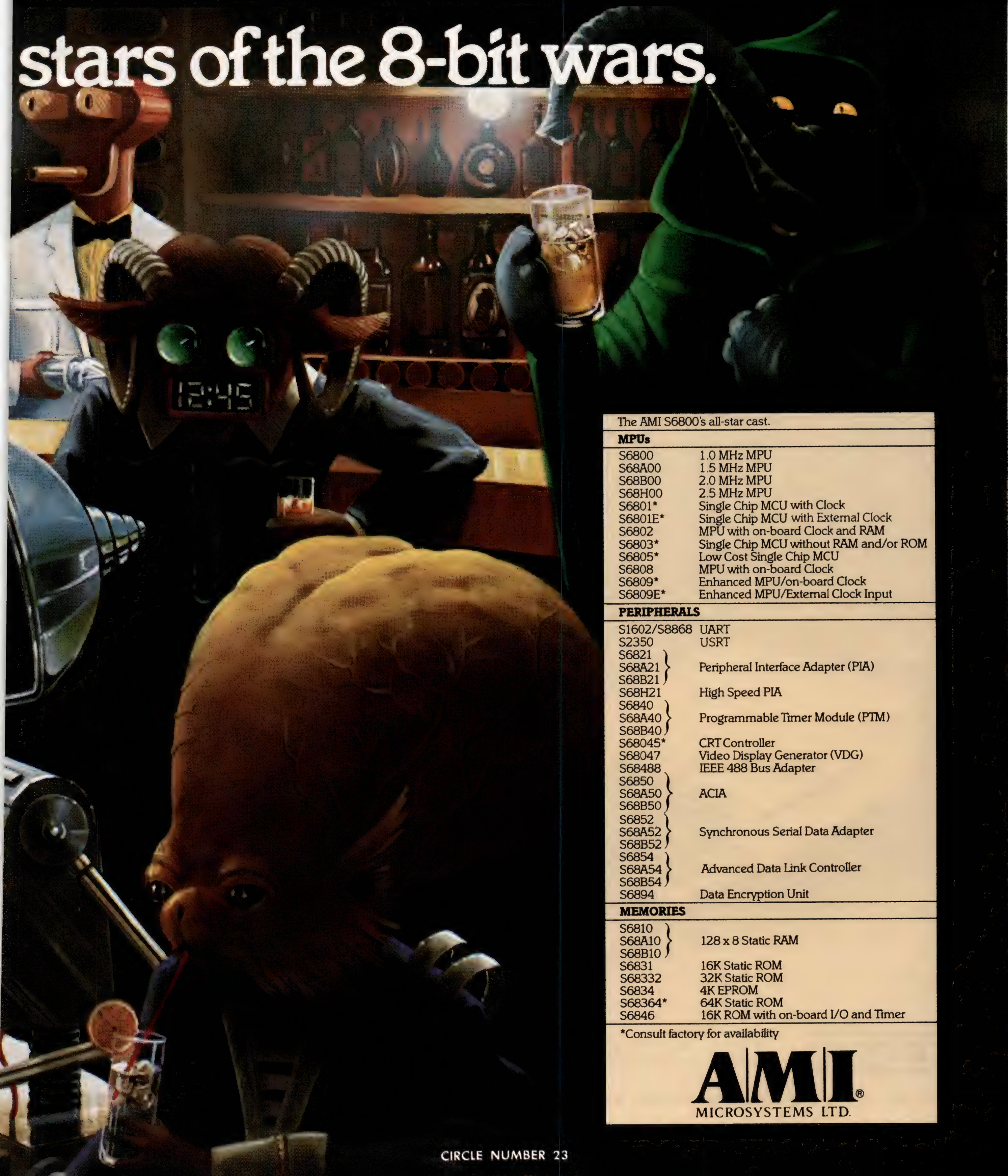
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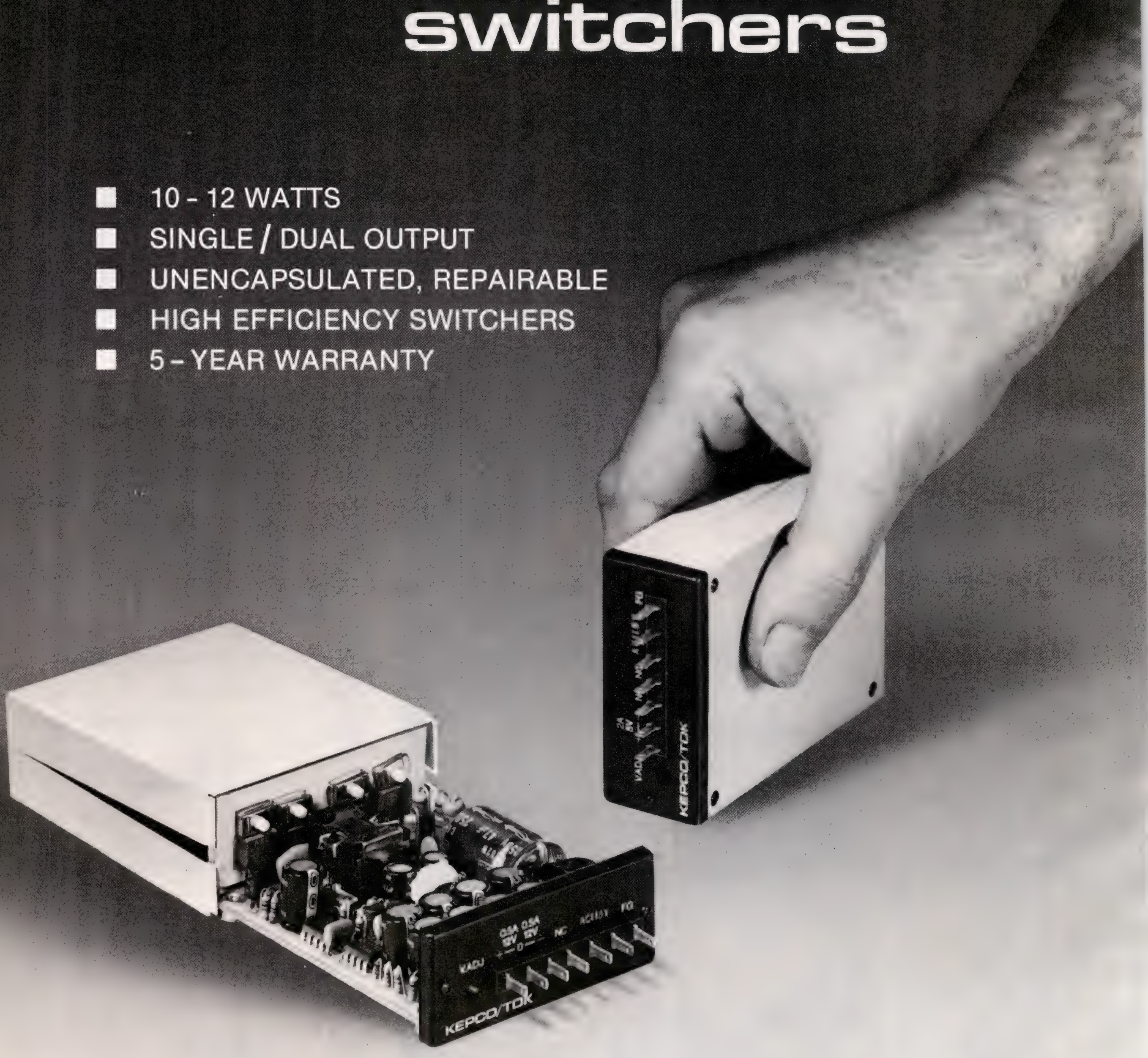

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CIRCLE NUMBER 24

Will the marketplace control the rf spectrum?

Marketplace pressures could make for a more efficient distribution of the radio spectrum than the present system of complex technical and administrative procedures, according to a study released by the National Telecommunications and Information Agency (NTIA).

The report, by Mathtech Inc. (Princeton, NJ), suggests several techniques for managing the rf spectrum, including auctions to allocate channels, band assignments in which some users would be granted several adjacent channels, frequency coordination agreements and freely transferrable licenses.

Under frequency coordination, for example, a new user would have to show that his system would not cause interference on the channels of other users. Failing that, he could improve the equipment of other users to eliminate interference or make cash payments to them to compensate for slightly higher interference levels.

NASA reviews space station designs

The National Aeronautics and Space Administration is looking over the designs that several U.S. aerospace firms have submitted for manned and unmanned space platforms. In April, the space agency expects to pick two of the preliminary designs for further development; the winning firms will receive $500,000 each for their continued work.

By 1986, space shuttles should be placing the first of the manned stations in orbit, despite the problems NASA has encountered in its space shuttle program. The stations will be used for scientific experimentation, industrial production and military observations.

To encourage private industry to use the orbiting platforms and the shuttle, NASA plans to provide free shuttle space for private experiments and guarantee full proprietary rights to inventions and processes developed in space. Among other prospects long-discussed in this area, high-quality semiconductor crystals may be grown in the vacuum and weightlessness of space.

Justice Department backs reform of patent policy

The U.S. Justice Department has given its qualified support to a House bill that would unify the government's policy toward patent rights for inventions arising from federally sponsored research and development projects. But the department spokesman urged the House Science and Technology Committee to bring its measure in line with a similar bill sponsored by the Carter administration.

Deputy Assistant Attorney General Ky P. Ewing said that both measures would grant government contractors some form of exclusive license for their inventions and give the government royalty-free rights to apply the inventions to its own uses. Both would give the federal agencies "march-in rights" to revoke exclusive licenses when national security was at stake or when the contractor would otherwise get an anticompetitive advantage harmful to the public interest.

Under the administration-sponsored bill, agencies would review the granting of an exclusive license before it was awarded; under the House measure, agencies would rely on the march-in rights section to police the license awards. The Carter bill would also give contractors exclusive patent rights only in markets they specify and allow the government to award nonexclusive licenses in other fields.

Hughes develops a missile that finds its own target

Under a $42.9-million contract from the U.S. Air Force, Hughes Aircraft Co. will build and flight test 16 prototypes of the Wasp—a missile that relies on a built-in terminal guidance seeker to find its target. Fired in clusters (or swarms) of ten or more, the Wasp will be programmed to fly to a target area and will then use an infrared or millimeter radar seeker to identify a specific target.

Because the missile locks on after launch, it can be fired even though the flight crew has neither seen nor designated a target. Hughes will evaluate both the infrared and the millimeter-wave radar seekers, to determine which provides the best identification of armored targets. The missiles will weigh about 100 pounds—about one-fifth the weight of the Hughes Maverick air-to-ground missile. Hughes is competing with Boeing Aerospace Co. to conduct the full-scale engineering development program.

Federal judge upholds equipment standards

A federal judge has upheld the government's standards for data processing equipment, overruling charges by several computer companies that the standards unfairly favor IBM Corp. and Japanese equipment manufacturers.

In dismissing the suit brought by Honeywell Information Systems Inc., Control Data Corp., Burroughs Corp. and Sperry Corp., Judge John Penn acknowledged that the specifications could harm those companies; but they were drawn up to save the government money—not to protect the interests of a few computer makers.

The four standards affect purchases of data processing equipment: They require standard connections between central processing equipment and peripheral hardware. Federal officials claim that manufacturers can use adaptors to connect their peripheral equipment to central computers made by another firm. The companies which filed suit argue that the regulations were written and issued without due process and that the retooling required would cost billions of dollars—effectively excluding them from the market.

Capital capsules:

The People's Republic of China has signed more than 180 contracts to process and assemble electronic products for more than 100 foreign firms. The contracted work, worth about $24 million, will be done at 89 plant locations, with advanced equipment, instruments and training provided by the outside companies. . . .**The public now has access to data tape files on more than 650,000 current patents.** The files of the U.S. Patent Trademark Office and of the Commerce Department's National Technical Information Service list the patents by classification, incorporate the full texts of patent applications and provide bibliographic abstracts showing the current status of the listed patents. . . .**An experimental procedure will estimate time and rate parameters in digital communications systems.** Commerce's National Telecommunications and Information Agency has developed a statistical method for making the estimates according to specifications in federal standard 1033. The agency's report (accession number 297-997/AS) is available through the National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161.

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CIRCLE NUMBER 25

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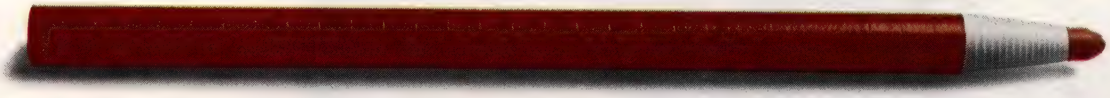

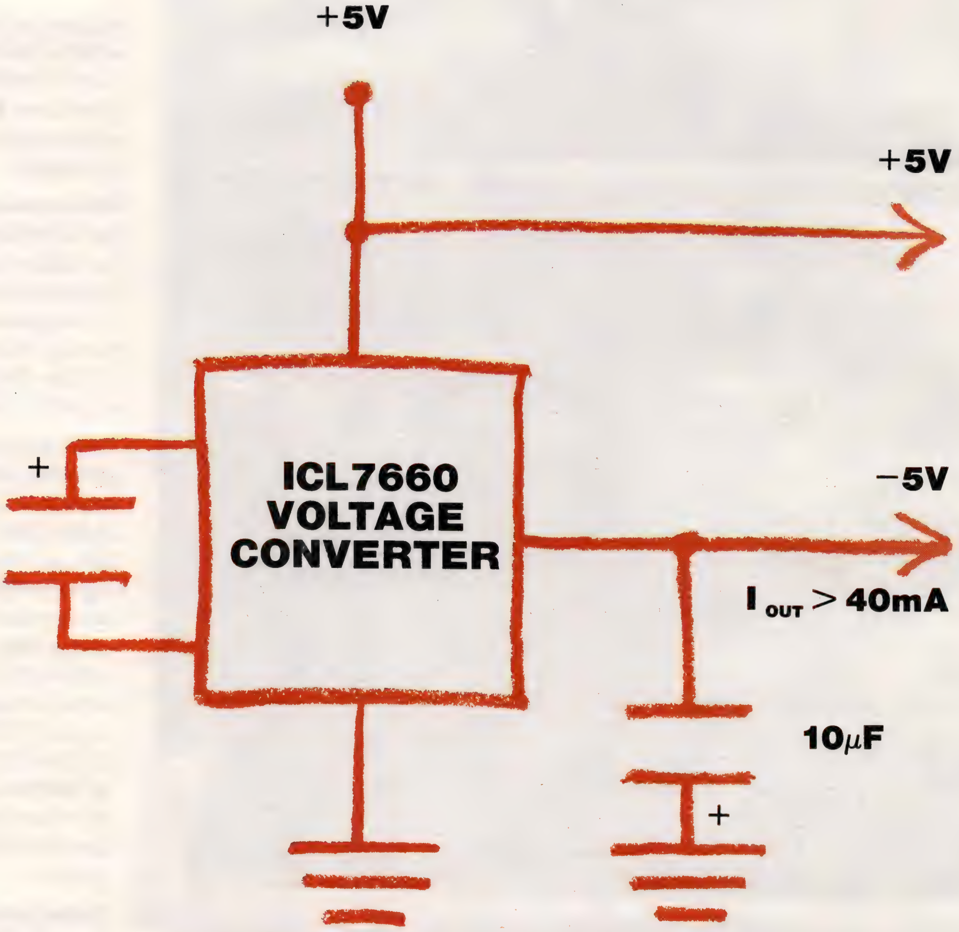

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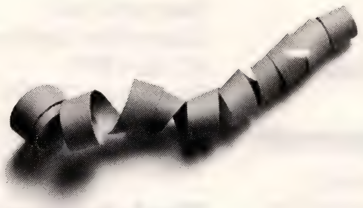

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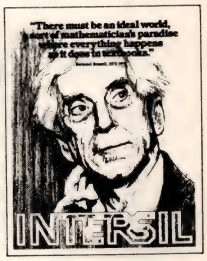
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Storm signals continue to flap on the economic yardarm—yet our business is booming, and our horizons seem clear. In the face of year-old cries of an impending recession, the electronics industry has maintained phenomenally steady forward progress.

Explosive first-quarter returns from many top performers signal continued balmy weather. Voluminous plant expansions and swelling employee ranks amplify the cry of "Full steam ahead."

Yet here and there, whitecaps appear, as if to warn of an unseen storm. Should all hands be on the lookout?

Looking astern may provide the answer. Experience reveals that businesses that are technology-driven prove remarkably immune to economic downturns; those that are market-driven become intertwined with the customer base, become subject to all the inflationary ills of that base—and may be doomed to founder.

Those whitecaps that won't go away may be bona fide telltales that much of our industry has forsaken innovation for unchanneled demand as the basis for growth.

Computers are signally in danger of becoming market-driven commodities. How dangerous is it to let products slide into the commodity category, with no breakthrough products ready to go? Ask the semiconductor industry, which suffered greatly in the last big recession because of poor planning, which led to overcapacity, overstaffing and underselling.

The products that sell during a recession are those that do more—a lot more—to boost a customer's productivity, while saving him money. Those products are the fruits of a steadfast commitment to innovation—and that means money given freely to research and development.

No industry owes more to innovation than ours. Innovation has fought inflation. Innovation has created jobs—and has saved them. Now, while our industry sails in what may be the eye of a colossal economic hurricane, is the time to recall not only the virtues of continued innovation but also the dangers in slowing research and development.

If the storm does hit, innovation is the only guarantee of safe passage.

Stan Runyon

STAN RUNYON
Executive Editor

Logic analyzers—sharp fault-finders getting sharper

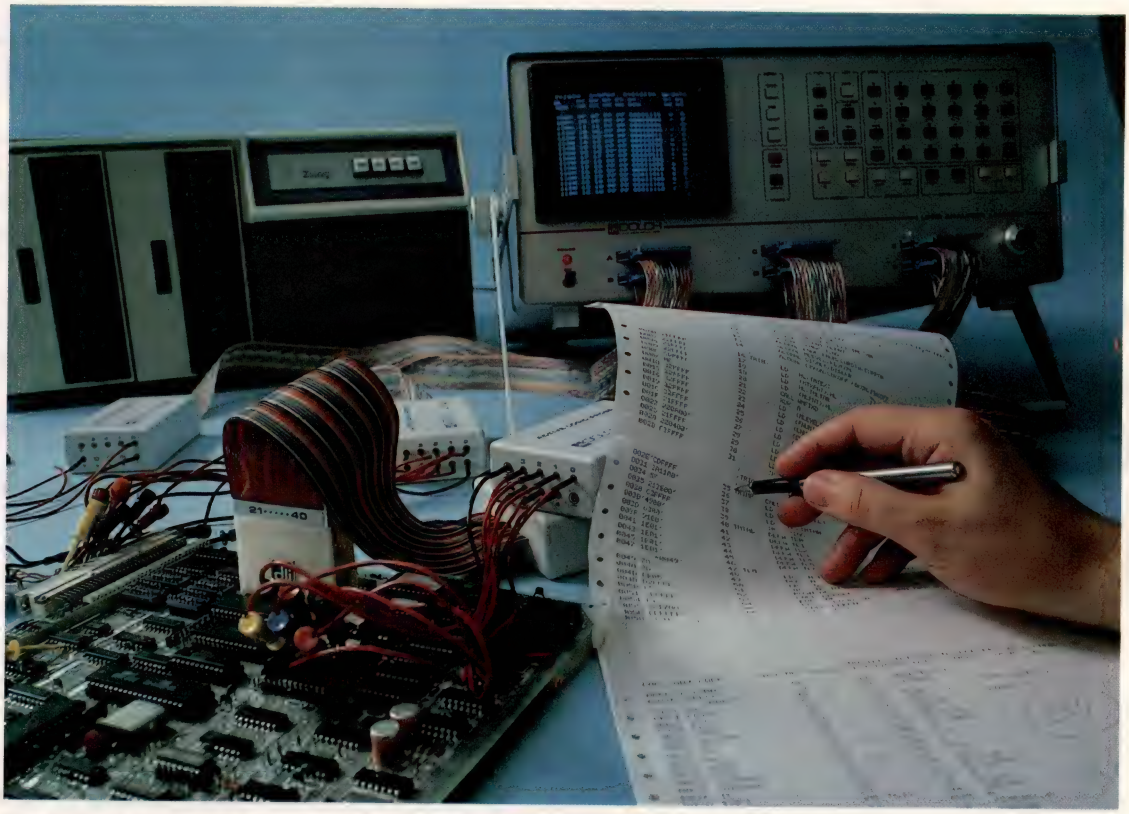
Logic analyzers are changing fast, as urgent testing needs step up the demand for both general-purpose and specialized test equipment. Once hailed as the oscilloscopes of the digital world, LAs are, in many cases, packing enough improved and new features to make their presence felt not only there but also in the analog world:

- Microprocessor-bus-demultiplexing capability is now being offered by most major equipment suppliers.
- Selective triggering is being improved to enable users to record, say, those same lines of code that malfunction every 1000 hours or so of operation.
- Analog channels make it possible to put real-time signals in the proper "scope."

Jonah McLeod
Instruments Editor

- Field-service capability is being added to LAs.
- Production testing, though just being added to them, is actually a natural for LAs since only slight additions need to be made to bench units.
- Diagnostics aimed at analyzing minicomputer problems are another recent addition that, considering the mini's enormous impact on the digital world, was a surprisingly long time in coming.

Bus demultiplexing is a testing requirement of systems based on microprocessors that time-share certain lines on the bus between address information and data. In the 8085, for example, eight lines carry half the memory address during a fraction of an instruction-execution time and data during another fraction. If it cannot demultiplex the bus, a logic analyzer will see just a steady stream of information and won't be able to clearly distinguish data from address.



Flexibility is the main feature of the LAM 4850 from Dolch Logic Instruments GmbH —besides 48-channels, each 1024 bits deep, it has three clocks for demultiplexing and several levels of sequential triggering for code analysis.

Bus demultiplexing requires at least 24 channels for 8-bit μPs and 32 for 16-bitters. It also needs multiple clocks to strobe the various demultiplexed components into the analyzer. While information is being dissected on a bus like the 8085's, one signal from the host system is used as a clock qualifier for each bus component to be sliced away. On the 8085 microprocessor, the Address Latch Enable signal (ALE) enables address transfer on the bus, while $\overline{\text{READ}}$ and $\overline{\text{WRITE}}$ do the same for data.

Tying them on

During analyzer operation, 16 channels are tied to bus lines 0 through 15, while another eight lines are tied to lines 0 through 7. The first group gathers address information, the second captures data. The clock qualifier for the 16 channels will be strobed by ALE, while $\overline{\text{READ}}$ and $\overline{\text{WRITE}}$ will provide clock qualification for the remaining lines.

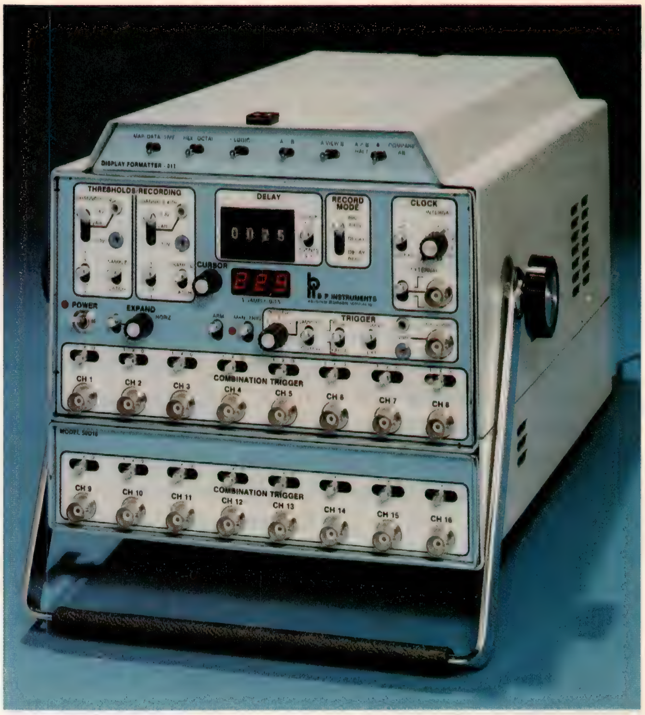
So far, logic analyzers that implement bus demultiplexing do it with minor variations. The 1610B and 1611A from Hewlett-Packard (Colorado Springs, CO) and the LAM 4850 from Dolch (Kontron) (San Mateo, CA) provide three clocks, while the PI532 and PI540 from Paratronics (San Jose, CA) and the K100D (with optional K100/32 input adapter) from Gould-Biomation (Santa Clara, CA) provide two.

In addition, most of these units display addresses and data in binary, hexadecimal or octal. The Dolch LAM 4850 and the HP-1611 also permit the bus information to be disassembled into the mnemonic code of the processor being monitored. The Dolch unit permits the operator to move back and forth between disassembled ASCII and its hexadecimal, octal or binary-equivalent source code.

Bus demultiplexing is a rather basic function compared to the logic debugging that ensues. As the levels of debugging increase, the LA might have to trigger on one or more or all of the following conditions: occurrence or nonoccurrence of the trigger word, then-after-n clocks, not-on-n clocks, before-n clocks, on-n clocks, and on-n occurrences of the trigger word. The Dolch LAM 4850 and 4832 provide such capability at four and three levels, respectively; the HP-1610B, seven; and the Paratronics PI540, offers the largest number to date, 16.

Multilevel advantages

Multilevel triggering proves extremely useful in the debugging of a program containing multilevels of nested subroutines. For example, the main program might branch to a subroutine that, in turn, is interrupted by another subroutine that is itself interrupted, and so on. Only an LA with multilevel sequential triggering capability would be able to follow the program execution through this elaborate path to a routine falling about six interrupts removed from the main routine.



Able to do both time and state-domain analysis, the Model 50D 16 from BP Instruments offers 16 channels, each 510 bits deep, and operates at a 50-MHz internal or external clock rate.

Other analyzers offer a wide variety of triggering capability, though at two levels. These include Gould-Biomation's K100 D and LA5000, E-H International's (Oakland, CA) LA1850 and Philips' (Mahwah, NJ) PM 3500 and PM 3540. Most others provide single-level triggering with options that permit one or two more levels to be added (for information on all of these, see table entitled "Logic Analyzers at a Glance").

One special type of triggering has risen to prominence after making its appearance on the HP-1615A: glitch triggering. With this capability, an operator can capture an elusive noise spike and trigger the data collection. This is useful in ferreting out noise-induced code problems. By ANDing the occurrence of a glitch with an erroneous branch out of the code, this abnormality can be recorded and later investigated. (This capability is not to be confused with glitch capture, which involves only the recording of the narrow noise spikes that seem to crop up everywhere in newly designed logic.)

In the HP approach, an 8-bit-wide by 256-bit-deep memory is reserved exclusively for capturing glitches. This way, the glitch can also be ANDing with the trigger word or used by itself to trigger the trace of the logic analyzer. However, the more recent Paratronics PI540 does not reserve a memory for glitches but detects the presence of a noise pulse, and triggers on it.

Digital, analog scopes unite

Beyond demultiplexing and triggering, analog channels—and with them, oscilloscope capability—are attaching themselves more and more to LAs. Scope capability is being added in two ways: by physically integrating analog oscilloscope channels, or by using an a/d converter to create a digital oscilloscope. The former method is used on the Philips PM 3540 (ELECTRONIC DESIGN, April 12, 1979, p. 159), and the latter on the Paratronics PI540.

In the PM 3540, a real-time, dual-trace oscilloscope is integral to the analyzer, not simply an add-on box or plug-in for the main instrument chassis (there are also separate front-panel controls). What's more, an internal interconnection permits a trigger from the analyzer to initiate the scope's dual-trace sweep.

Incidentally, having an integral oscilloscope and logic analyzer is not a novel concept, as exemplified by the Tektronix (Beaverton, OR) 7D01 logic analyzer, itself a plug-in module for the company's 7000-series oscilloscope. The 7D01 occupies two of four plug-in slots; the other two are available for a scope's vertical amplifier and time base. In addition, the analyzer can trigger the scope internally.

Real-time analog capability does have its disadvantages: One-time events cannot be captured and displayed on the scope; they must be repetitive. Hence, software loops must be created to view infrequently occurring or nonrecurring pulses. One unit, the PI540, gets around this drawback by equipping a single channel with a high-speed 50-MHz a/d converter. The channel ends up with a 15-MHz bandwidth and 6 bits of resolution. The converter feeds 1024 bits into memory-storage space. Even though this configuration provides only one channel, it does what the analog product cannot do—capture, store and display one-time events.

Moreover, as implied, the a/d channel can be triggered by the logic analyzer's digital channels. This channel is ideal for monitoring slow-moving analog signals like those found on the low-frequency lines in an RS-232-C communications link, in the electromechanical controls of printer, disk and tape drives, or in other computer peripherals.

There are also drawbacks in the a/d implementations, foremost being the channel's relatively low sample speed. In essence, the analog channel is restricted to monitoring lower-frequency signals. However, for these applications, the analyzer is quite capable. Eventually, as a/d converters reach sample frequencies as high as 100 to 200 MHz, this kind of waveform analyzer will offer more of the resolution and accuracy of an oscilloscope.

Most instruments offering an oscilloscope can generate an external trigger. Some, like the Tektronix unit, put analyzer and scope in one package. But none provides this capability as inexpensively—under \$4000—and as conveniently—in a light, portable package—as the Philips 3540.

Combining analyzer and oscilloscope makes a powerful field-service tool. The Philips unit is priced within the reach of most service facilities, under \$5000, but the Paratronics unit, at around \$9000, may be a bit rich for most field-service shops.

Though small, the 532 from Paratronics offers big-instrument features like bus demultiplexing, using two external clocks, and five types of trigger delays.

Able to capture 18 channels of logic input at a 50-MHz clock rate, the LA 1850 from E-H International can also handle ECL, TTL, and variable-input levels.

Twenty active inputs via four high-impedance pods are available with Gould-Biomation's LA5000. On the logic analyzer's data inputs, 4-bit words can be clocked at a fast 50 MHz, while 8 and 16-bit words are clocked at 25 and 12.5 MHz, respectively.

Taking a different tack to serve troubleshooting requirements, Tektronix offers the 308 Data Analyzer, an eight-channel LA, with integral CRT display, that does time and data-domain measurements as well as single-channel serial-data analysis. Serial capability is especially useful with bit streams, like those found on an RS-232-C communications link. In addition, the unit offers signature-analysis capability. However, the real news here is that it's all together for the first time and available for around $3000.

Other products addressing field-service applications include Gould-Biomation's 2710, HP's 1602A, Paratronics' PI532, BP Instruments' (Cupertino, CA) 20D, Epic Instruments' (Foster City, CA) Model 78 and E-H International's MBA-1.

Standing out on the Biomation unit is its dual muscle: the ability to record 8-bit μP-program execution steps on top of its general-purpose logic-analyzer capability. Another attraction: a built-in, two-function calculator that adds or subtracts in hex, octal or decimal—especially helpful when debugging relative addressing in a μP program.

Like the Biomation unit, the HP instrument is general-purpose. But it also can debug the IEEE-488 bus. With an optional adapter and test probe, the analyzer connects directly onto the bus, and monitors data transfer and bus-handshake operations.

But where the 1602A has 16 input channels, the 2710 has 27. On the other hand, Paratronics' general-purpose PI532 boasts 32 input channels. More noteworthy than that, however, is the trait it shares with its larger companion, the PI540—two clocks that allow it either to demultiplex the data and address or to control information from a bus and route it to each of its two 16-wide input channels. This is a powerful feature for a field instrument.

Another feature particularly useful to field service is an optional RS-232-C interface, which allows a field technician to connect the instrument to a distant depot facility via the communications link. Once the link is established, the depot can examine the data contained in the analyzer's memory and can advise the technician on whatever additional troubleshooting steps could be taken.

In addition to tying into a computer system, the RS-232-C interface can help dump information to an intelligent peripheral. For example, it might be desirable to record the data acquired during fault isolation in the field for later analysis in the lab. This port can also be used to load data into analyzer memory. One company currently offering an intelligent minifloppy capable of transmitting or receiving data over an RS-232-C link with a logic analyzer is Techtran (Rochester, NY).

The Gould-Biomation, HP and Paratronics field instruments described operate exclusively in the state domain. Two other companies, however, BP Instruments and Epic Instruments, offer units with both state and time-domain capability. But unlike the 1602A, the 2710 and the PI532, which offer an integral LED readout, the BP Instruments 20D and the Epic Instruments Model 78 require a CRT to display captured data.

An eight-channel-wide, 256-bit-deep instrument, the 20D runs at a synchronous 30-MHz rate and at a 20-MHz asynchronous rate. Not only does it offer most of the features of a general-purpose analyzer, including a 10-ns glitch capture, but it also meets the under-$2000 field-service cost criterion, something it shares with the Epic unit. Besides being a general-purpose, time and state-domain instrument like the 20D and offering most basic LA functions, including 10-ns glitch capture, the Model 78 has 16 channels, each 1024 bits deep.

The E-H International MBA-1 is another portable field instrument. Its virtues include logic triggering and 32-wide, 128-deep memory. With a general-purpose probe and special probes for the 8080, 6800 and Z80 microprocessors, the unit can monitor μP operation in situ.

On the production line

With the RS-232-C capability now emerging to serve field-service applications comes an asset that also suits territories closer to home but hitherto not fully developed. The asset is the ability to tie to a computer. The territory is production testing. Put this together with the IEEE-488 capability found on most analyzers as well as a large reference memory and sophisticated triggering, and the result is considerable support for automatic testing functions.

How do these seemingly unrelated features come together to provide automatic test capability? The memory ties the instrument, via one of two fairly high-speed communication links, to a computer or controller. In the analyzer, the reference memory allows the computer to load the analyzer with known-good

Speed is the forte of the Philips 3500 Analyzer, a one-year-old contender which runs at a 100-MHz clock rate and captures glitches in 3 ns.

Logic analyzers at a glance

Analyzer	Channels	Clocks	Trigger modes	Source memory (channels × bits)	Display capability	Glitch capture	Reference memory comparison	Trigger delays	Bus de-MUX	Bus interface	Circle No.
BP Instruments 50D 16	16 state or time domain	50 MHz internal or external	Pretrigger, post-trigger; optional level of trig capability	16 × 510	16-channel time diag; optional binary, hex, & octal; CRT optional	5 ns	Ch 1-8 can be compared to ch. 9-16	Delay by no. of sample clocks or no. of trigger events	Optional via transitional clock	None	**451**
BP Instruments 20D	8 state or time domain	20 MHz int or ext	Pretrigger & post-trigger	8 × 256	8-ch time diag; CRT optional	10 ns	None	Delay by no. of sample clocks or no. of trigger events	Not available	None	**452**
Dolch (Kontron) LAM 4850	48; 3 sets of 16 state or time domain	3 clocks to 50 MHz int or ext	4 sequential trigger words in a "then," "then not," AND or OR logic sequence	48 × 1024	16-ch time diag; binary, octal, hex, ASCII and 2 optional decodings; 3 menus, CRT standard	5 ns	48 channels wide × 1024 bits deep	5 individual delays and occurrence counters for various delays	Optional via personality probes	RS-232-C IEEE-488 (optional)	**453**
Dolch (Kontron) LAM 1600 and 1632	32; 2 sets of 16 state or time domain	20 MHz int or ext	3 sequential trigger words in a "then," "then not," AND or OR logic sequence	32 × 1024	16-ch time diag; binary, octal, hex, ASCII, CRT standard	10 ns	32 × 1024	5 individual delays and occurrence counters for various delays	None	Optional RS-232-C	**454**
E-H International LA 1850	18 state or time domain; optional expansion	50 MHz int or ext	Pretrigger, posttrigger & 1 optional sequential trigger word	18 × 512	18-ch time diag.; 16-ch binary, octal, hex; map display, CRT optional	5 ns	16 × 51	Delay by no. of clocks or no. of trigger events	Optional via personality probes		**455**
Epic Instrument Model 78	16 time domain	20 MHz int or ext	Pretrigger or posttrigger	16 × 1024	16-ch time diag; CRT optional	10 ns	None	Delay by no. of clocks or no. of trigger events	None	None	**456**
Gould-Biomation K100 D	16 state or time domain, clock, qualifier, & 2 trig. qual; optional expansion	100 MHz int 70 MHz ext	Pretrigger, posttrigger 2 levels of triggering	Record memory (16 × 1024); storage memory (16 × 1024)	16-ch time diag; 16-ch binary, octal hex	5 ns	16 × 1024	Delay by no. of clocks or no. of triggers at one trigger level	Optional via 32-ch input adapter	IEEE-488	**457**
Gould-Biomation LA5000	16 state or time domain, 2 qualifiers, 1 clock, 1 ext trig. 1 ext arm	Ch.1-4, 50 MHz; Ch. 5-8, 25 MHz; Ch. 9-16, 12.5 MHz	Pretrigger, post-trigger; 2 levels of triggering	Record mem (16 × 256); storage mem (16 × 256)	16 ch time diag.; 16 ch binary, octal, hex	5 ns	16 × 256	Delay by no. of clocks or no. of triggers at one trigger level	None	None	**458**
Hewlett-Packard 1610B	32 state domain	Accepts 3 10-MHz ext clocks combined for 32 chs split 16/16 or 16/8/8	Pretrigger, posttrigger; seven levels of triggering	32 × 64	Binary, octal, hex CRT standard	None	32 × 64	Delay by no. of clocks or no. of triggers at each trigger level	Three separate clocks permit bus de-MUX standard	IEEE-488 optional	**459**

Hewlett-Packard 1615A	8 time or state domain; 16 state domain	Int, 2 Hz to 20 MHz; ext, dc to 20 MHz	Pretrigger, posttrigger, glitch trigger, six types of triggering in time mode & two levels in interactive mode	24 × 256 8 × 256 (glitch mem)	8 ch time display or 16 ch binary, octal hex; 24-ch binary, octal, hex, CRT standard	5 ns; separate glitch memory	None	Delay by no. of clocks or no. of trigger occurrences	None	IEEE-488 optional	**460**
Moxon 745	16 state domain	20 MHz ext	Pretrigger or posttrigger	Record mem (16 × 1024); storage mem (16 × 1024)	1 ch serial or 16 ch parallel state diagram display; binary, octal, hex	None	16 × 1024	Delay by clock only	None	Optional IEEE-488	**461**
Paratronics PI540	8 state or time domain, 32 state, 1 waveform	On 8 ch 50 MHz, int. or ext; on 32 ch two 15-MHz clocks	Pretrigger, post trigger, glitch trigger on 8 ch; 16 levels of triggering	32 × 250 or 10 × 500 and 8 × 1000	16-ch time diag; binary, octal, hex, ASCII via optional RS-232-C serial link	5 ns only on 8 timing channels	32 × 250	5 types: after n, not on n, before n, on n, and n occurrences	Two separate clocks permit Bus d-MUX standard	Optional RS-232-C, IEEE-488	**462**
Paratronics PI532	32 state	2 ext 12 MHz each	Pretrigger, posttrigger	32 × 250	Binary, hex, octal	None	32 × 250 up to 8 auxiliary 32 × 250 memories	5 types: after n, not on n, before n, on n, and n occurrences	Two separate clocks permit bus de-MUX standard	Optional RS-232-C, IEEE-488	**463**
Philips PM 3500	16 state or time domain	100 MHz int or ext	Pretrigger, posttrigger, optional 2-level sequential trigger; also expands trigger word by 16 bits	16 × 505	16-ch time diagram binary, hex, octal CRT standard	3 ns	Split source to produce two 16 × 256 memories—one source, one ref	Delay by clock pulse	None	None	**464**
Philips PM 3540	16 state only & 2 real time analog scope channels triggered by logic-analyzer trigger word	10 MHz ext	Pretrigger, post trigger, optional 2-level sequential trigger; also expands trigger word by 16 bits	16 × 64	Binary, hex, octal and waveform (2 chs) CRT standard	None	16 × 64	Delay by clock pulse	None	None	**465**
Scanoptik DM11	16 state only	External	None: Unit records last 256 transactions on LSI-11 bus	16 × 256	None: Operator retrieves stored data, via host system's console key command	None	None	None	None	Unit ties directly on LSI-11 Q-bus	**466**
Tektronix 7D01	16 time & state domain	16 ch at 20 MHz, 4 ch at 100 MHz, 8 ch at 50 MHz; int clock, 100 MHz; ext clock up to 50 MHz	Pretrigger, center trigger, posttrigger, one level; added level and wider trigger with companion instrument	8 × 252	CRT companion instrument display via companion formatter; hex, binary, octal, ASCII, GPIB mnemonics, 16-ch time diagram	15 ns, 5 ns via companion instrument	8 × 252	Delay by clock pulse in parallel	None	IEEE-488 bus-monitor decoding	**467**
Tektronix 308	8 time & state domain	20 MHz int or ext	Pretrigger, posttrigger, 1 or 2 level depending on mode	8 × 252	8 ch time diagram; hex, binary, and octal or ASCII	5 ns	8 × 252	Delay by clock pulse or by trigger event depending on mode	None	RS-232-C	**468**
Vector Associates 1625	16 state domain	25 MHz ext	Posttrigger, single-level trigger	16 × 256	CRT standard, 16 ch state diagram display	7 ns	None	Delay by clock pulses	None	None	**469**

data. The sophisticated trigger allows the instrument to compare the known-good data in reference memory with data samples from the unit under test.

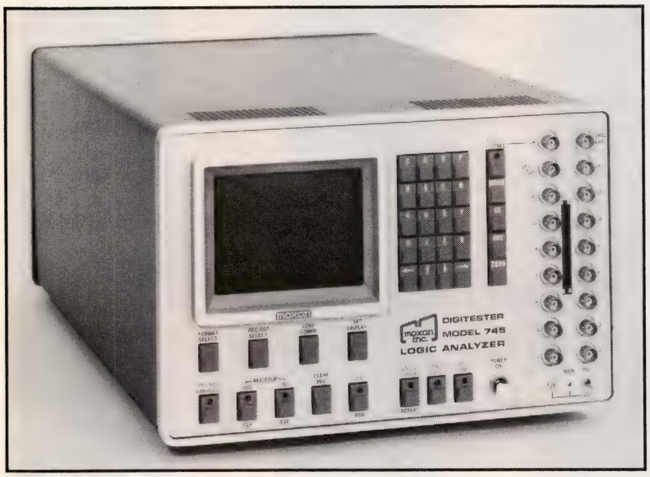
For testing equipment or boards with more memory than is contained in the analyzer's reference memory, a block of known-good data is downloaded and tested against what is monitored in the unit under test. If the test proves good, operation is suspended momentarily while the next block is downloaded. Once the reference memory is relocated, testing resumes.

Instruments sporting this capability include the Dolch LAM 4850 and 1600/1632, the Gould-Biomation K100D, the HP-1610B and 1615A, and the Paratronics PI540. In addition to these high-end instruments, any analyzer with IEEE-488 or RS-232-C capability provides some degree of production-testing capability.

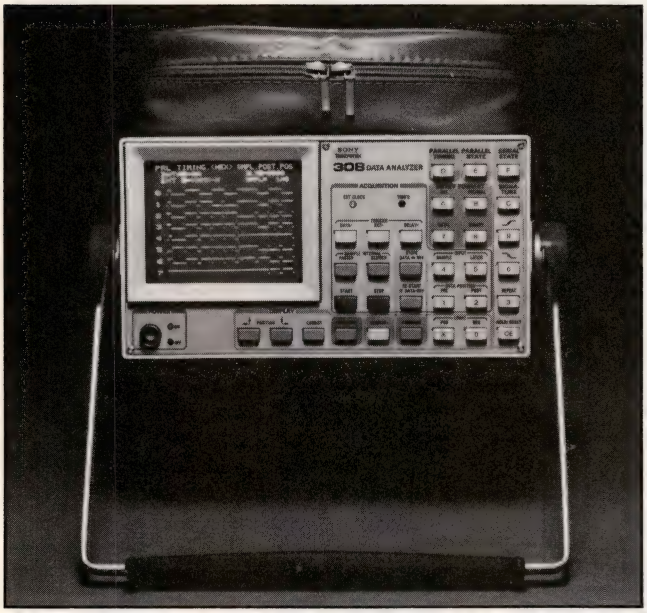
Like production testing, minicomputer troubleshooting has up to now not been an active area for LAs. Two problems have kept analyzers out of minicomputer applications: getting into the system and coping with the wide variety of architectures.

Getting into the system means boarding the minicomputer bus. With its 16 bits of address and 16 bits of data, that requires getting onto a backplane. However, that problem is a cinch compared to the second problem—the architectures of the various minicomputers are all different.

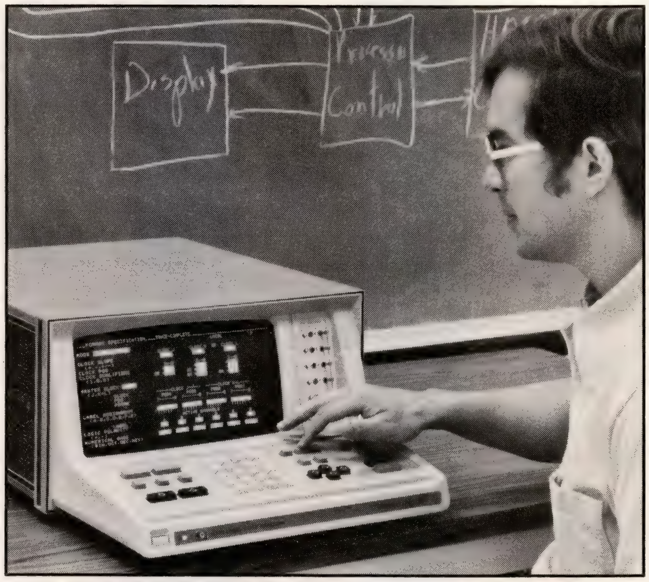
The DEC PDP-11 is asynchronous. An LSI-11 from the same company is not only asynchronous, it's also multiplexed. The HP-1000 is not only multiplexed, it's also inverted-multiplexed depending on whether a read or a write is occurring. Thus, the problem is one of preprocessing the information seen by the analyzer so that no matter which minicomputer program execu-



With a deep, 16-kbits-per-channel memory and 20-MHz clock rate, Moxon's Model 745 logic analyzer is well suited for diagnosing RAM propagation-delay problems.



Field-service applications are prime territory for the Tektronix 308, which combines signature-analysis capability with parallel time and state and serial-state.



With its three clocks, the 1610B, a highly capable state-domain instrument from Hewlett-Packard, can demultiplex just about any microcomputer bus. With its seven levels of triggering, the 1610B can trigger on very selective parts of a program being debugged (top). Another HP analyzer, the 1615A, displays simultaneous time, state and glitch information (bottom).

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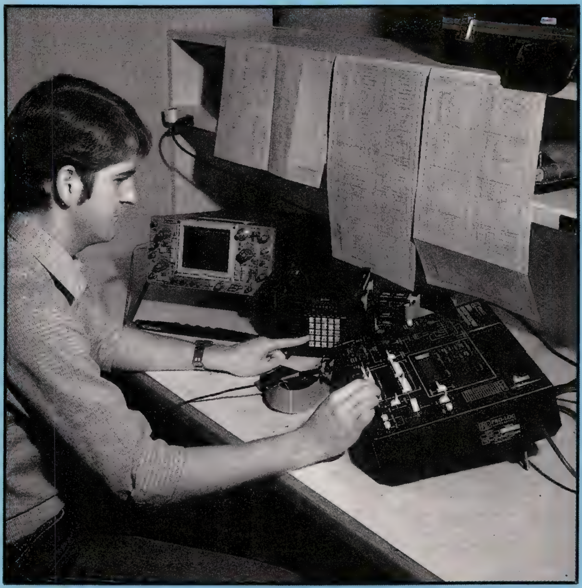
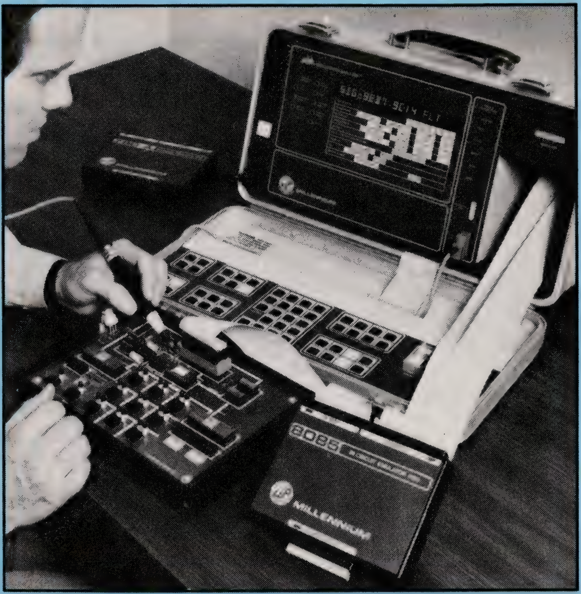
CIRCLE NUMBER 28

Are these logic analyzers?





Just what constitutes a "pure" logic analyzer is difficult to say. Many instruments are available for logic troubleshooting, some of which add their own personalities to the set of characteristics possessed by most logic analyzers. Among them are (clockwise, from upper left) the Pro-Log M824 system analyzer, a troubleshooter that is specifically targeted at Z80-based microprocessor systems; the Millennium Systems Series 4000 Microsystem Analyzer, a universal µP test instrument which combines time domain and signature analysis with in-circuit emulation; the Step Engineering Step-2 microprogram tester, which can be termed an analyzer, development system or even a computer; and the AQ Systems AQ6800 microprocessor analyzer, another unit aimed at one µP, Motorola's 6800. Each of these four instruments brings different capabilities to analysis.

tion is monitored, the same address and data on the analyzer CRT are always indicated.

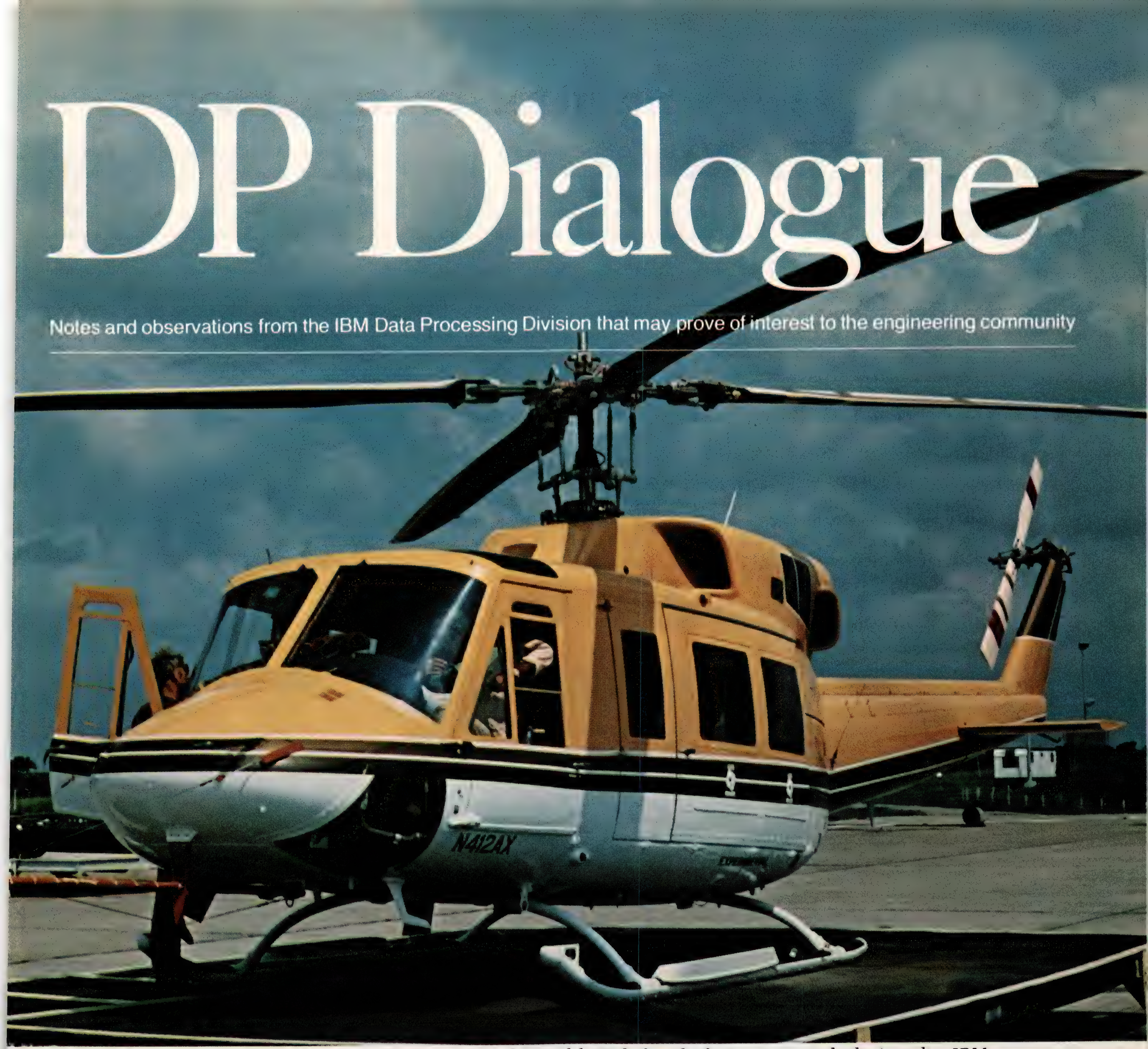
One logic analyzer addresses both problems: HP's 1610B. It offers a line of special probes for various popular minicomputers, which not only eases the problem of connecting into the computer but also handles the architectural differences. For those minis for which no special probe exists, the company offers a general-purpose probe that can be configured for a special computer type.

One company offering logic-analysis capability specifically for the LSI-11 is Scanoptik (Rockville, MD), whose DM-11 resides in the host computer at all times. It operates by continuously gathering the last 256 words of data and/or address on the 16 address/data lines of the LSI-11 Q-bus. If the computer halts for any reason, the last 256 words of data on the bus in the DM-11 can be retrieved and used to analyze the cause, no matter what kind of fault that is.

Two new LAs reflect the demand for ever more channels. The Moxon (Irvine, CA) 745 and the Vector Associates (Yaphank, NY) 1625 both offer 16 channels as well as pre and/or posttriggering capability. State-domain only instruments, they also demonstrate that frequencies need not be high for such units—the 745 has a 20-MHz clock, the 1625 a 25-MHz clock. ■■

DP Dialogue

Notes and observations from the IBM Data Processing Division that may prove of interest to the engineering community



Bell Helicopter knows the weight of new designs, such as this Model 412, before the first prototype is built. An online IBM computer keeps tabs on the weight of 20,000 separate parts of the vehicle.

Bell Helicopters Lift Off Without an Extra Ounce

"We save money and our customers get a better, safer product, through the use of a data system to keep track of the weight of a vehicle as the design progresses," says Richard Mathieson of Bell Helicopter Textron. Mathieson is group leader, weight management systems. "Before we put the first prototype model on the scale, we know its weight within one-half percent.

"A helicopter must meet a performance specification – a required air speed, payload and fuel range – and success depends on controlling its weight."

At Bell, a computer stores the weight of each part of a complete helicopter – structural members, pumps, tubing, even screws and rivets. In excess of 100,000 separate parts may be interrogated through the Weight and Value Engineering System (WAVES), which runs on an IBM System/370 Model 168 computer at the company's Fort Worth, Texas, headquarters.

"With the online system," Mathieson notes, "engineers can enter the weight of any new or revised parts and assemblies directly at terminals. Paperwork is eliminated, saving 2,000 to 3,000 engineering manhours a year, and information is more accurate and complete. Weight is now current daily: a designer can push a button and obtain the vehicle or component weight within seconds.

"At the beginning of a new design, we enter estimated weights for major sections of the helicopter. Then, as the design progresses, these estimated weights are replaced by more detailed calculated weights, and finally by measured ones.

"An accumulation of small differences can easily cause a design to be overweight," he continues. "Now we catch any such trend much earlier. And WAVES is really invaluable when a proposal is needed on a tight schedule. We can do many more tradeoff studies – cost vs. weight – in the same amount of time. If required, we can get two or three turnarounds per day, as against days for one turnaround under the old system. When last minute changes are required, WAVES can redo the calculations in a few minutes."

Advertisement

COMBIMAN Sits in for Air Force Pilots

Can a U.S. Air Force pilot readily reach all of the hundreds of controls typically found in a high-performance aircraft? Can he see all of the indicators? How well can he see outside the plane?

Today, at Wright-Patterson Air Force Base in Ohio, the designer of a new plane can answer such questions quickly and easily, by manipulating the COMputerized BIomechanical MAN-Model (COMBIMAN): a model of a human figure in an aircraft cockpit or work station. It permits the designer to sketch a work space around the figure directly on the screen of a computer terminal, using a light pen and the keyboard.

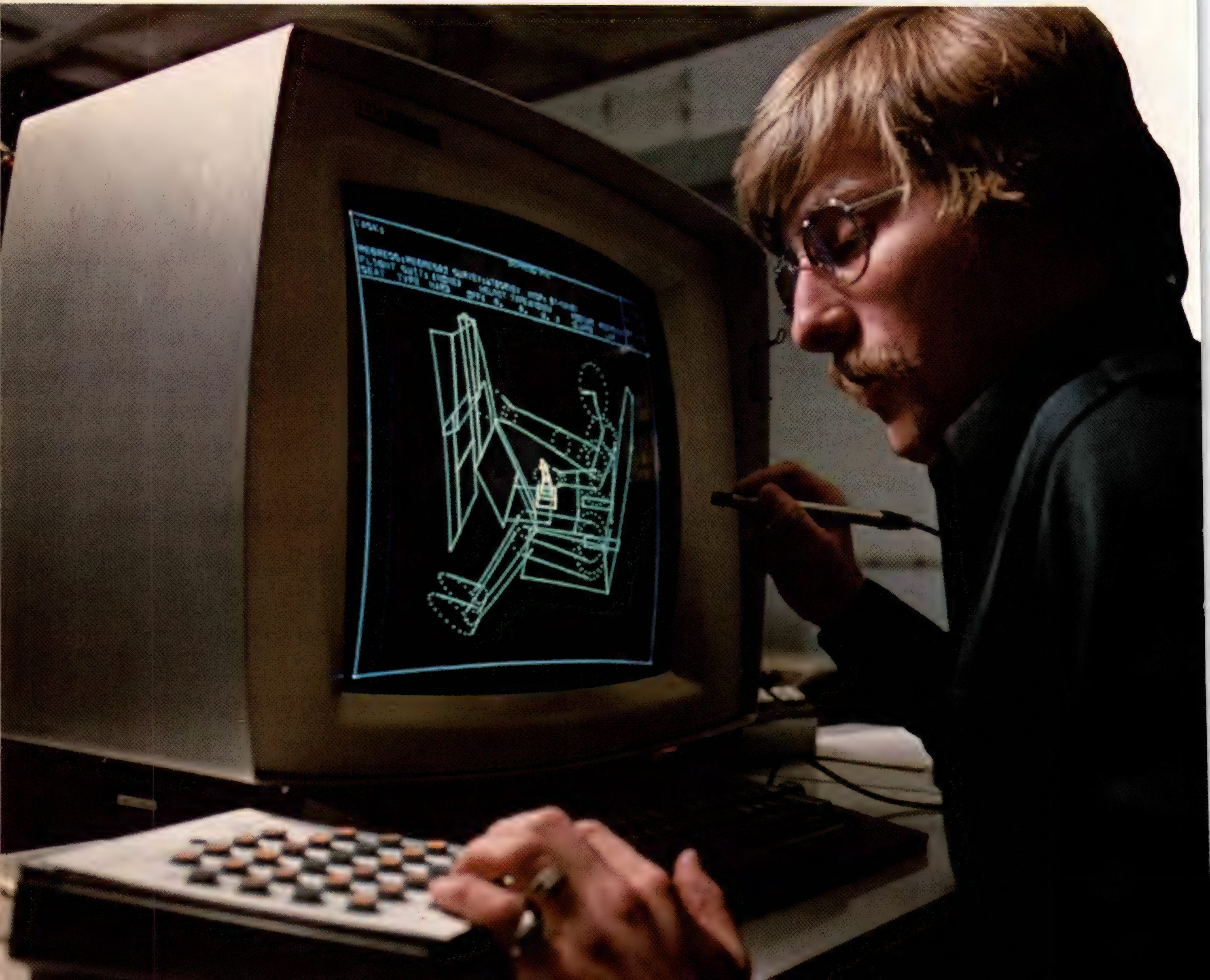
By touching the light pen to a "menu" of options, the user can select the variables that affect movement, reach, and sight lines, such as the size of the pilot, type of harness and clothes. With the cockpit layout and the human figure visible in the display, he can command a programmed "reach" to any selected point. The figure then executes a five-step reach, showing clearly whether – and how easily – a pilot can perform the same operation. The user can vary the proportions of the figure, using realistic combinations of human measurements stored in the computer. He can adjust the work-station design by moving, rotating, adding or eliminating elements.

The program was developed by the University of Dayton Research Institute under the sponsorship of the Aerospace Medical Research Laboratory of the Air Force Systems Command. Says Dr. Joe W. McDaniel, who directs the COMBIMAN project: "In the display, the workspace is very easy to modify, to experiment with, so the designer can try many more possibilities. When the physical mockup is first built, it will be much closer to optimum."

The figure can be made to lean or turn its head in order to calculate realistic sight lines for pilots with various body measurements. As with the hand, the reach of the figure's foot can be checked to insure that a pilot can readily reach the rudder control or other pedal. As the user builds a complete workspace, the computer – an IBM System/370 – accumulates the details. At any time, the system can be commanded to generate a plot of the design on paper.

"COMBIMAN lets the workspace designers get involved much earlier in a project," McDaniel adds. "This avoids later costly retrofit, or the need to compromise on performance."

The COMBIMAN human figure and workspace can be projected on the screen of an IBM 2250 Graphic Display Terminal in an off-axis perspective view. The designer can test and modify a workspace by interacting directly with the computer through the terminal.



ternational Harvester farm tractors are designed at the company's Hinsdale, Illinois Engineering Center. CADAM, the computer-based design system, has improved the quality of engineering drawings as well as the productivity of designers and draftsmen.

CADAM® Draws the Tractor that Draws the Plow

Using the computer as a drafting aid, ternational Harvester now develops ngineering drawings much more rap- ly: the gain in productivity is sometimes high as 20 to one, and averages be- veen two and three to one.

At the company's Engineering Center Hinsdale, Illinois, the Computer- raphics Augmented Design and Manu- cturing (CADAM) system is used to esign farm tractors and implements. omments E. J. Wynard: "We see the big- est gains where there is some repetition symmetry, or where we can reuse draft- ng work already in the computer mem- ry. For example, in an assembly drawing e can incorporate previously stored rawings of parts. CADAM lets us change ne scale of an element, rotate or move it, replicate it any number of times. We eep a large number of frequently used or tandard items in an online library, where ney can be incorporated with the touch of light pen."

Wynard is manager of engineering in- ormation systems for the Agricultural Equipment Group. He points out that ne drawing can be superimposed on an- ther, or movable parts can be viewed in several positions, to check clearances or interference, or look for drawing errors. The engineer or draftsman works at an IBM 3251 Graphic Display Station, online to a System/370 Model 138 computer.

"There has been fantastic acceptance by both experienced and novice users," Wynard notes, "because CADAM uses familiar drafting techniques. When we want to change or correct a drawing, we can rework it and get the revised drawing to the shop in a few minutes. CADAM lets us analyze more design possibilities in a limited time."

Adds Wayne Orkwiszewski, designer of agricultural implements: "There are fewer 'downstream' errors, because the drawings are accurate, detailed and readable. There is less scrap, and we build fewer design models.

"On large implements, there is a lot of repetitive detail and mirroring – left and right parts – the kind of thing CADAM handles very well. It's also good for developing a series of variations on a basic design. A family of hydraulic cylinders, for example, appeared in various sizes and was very complex, with many sectional views. One model required 79 drawings. We put the basic design in the data base, then adapted it without any further drafting by changing dimensions and rescaling certain drawings."

Adds William Knapp, manager of implement engineering: "The reaction of the professional people has been enthusiastic. They come in to work on their own time, and they accept inconvenient hours to get time on the system."

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CIRCLE NUMBER 29

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Edward T. Rodriguez, President, Theta-J Corp.,
208 West Cummings Park, Woburn, MA 01801.

A special family of solid-state relays will bring the high isolation of optocouplers, the high voltage capabilities of electromechanical relays and the fast switching speeds of power MOS (DMOS) to switching applications. This means that the OptoMOS devices will respond to low-level TTL signals, yet control high-current (ac or dc) and high-voltage loads with minimal on-resistance, and will switch on or off in less than 0.1 ms. In addition, the low-cost semiconductor devices should replace reed relays, phototriacs and other types of optocouplers on analog-I/O boards, automatic test equipment, telephone switching equipment and data-acquisition systems.

The first member of the OptoMOS family, the OFM-1A, responds to TTL signals on the order of 15 mA at 5 V, and controls up to 300 V ac or dc and 0.25 A (Fig. 1). On-resistance is rated at less than 20 Ω.

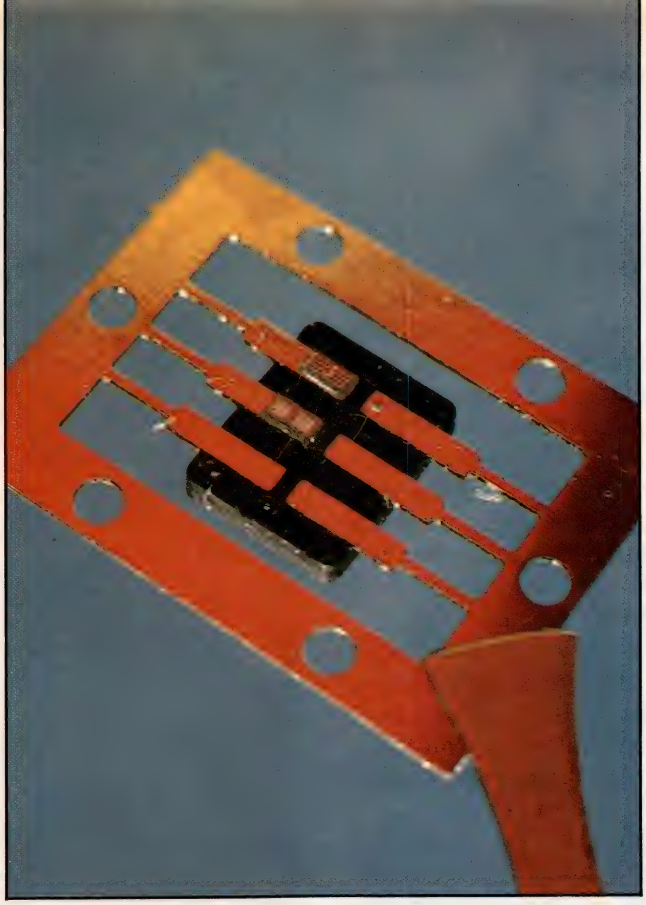
Switching speeds are less than 100 μs max, and in some cases drop down to 10 μs. The device, in fact, can be programmed to turn-on at speeds somewhat different from those at turn-off. Relays that turn off slightly faster than they turn on are useful in ATE, IC testing and other break-before-make contact applications.

Future versions of the OFM-1A will incorporate the break-before-make feature in an SPDT relay. Other versions will switch 400 V ac or dc, 2 A, with an on-resistance of 0.5 Ω, and may serve as the long-awaited "universal switch" in programmable-controller applications.

For now, however, the OFM-1A impresses by incorporating the same high isolation and off-state resistance of electromechanical relays in a much smaller, less expensive package. Isolation is better than 2500 V between the control and load signals (and the device has been tested successfuly to 5 kV). What's more, with 300 V across the load, the leakage current is less than 300 nA. The off-state resistance, therefore,

is typically better than 1000 MΩ, which approaches the outstanding 10^{12} Ω open-circuit resistance ratings of reed relays.

Unlike high-performance reeds, however, which are typically rated at 1-million operations under load, and cost as much as $10 apiece, the OFM-1A comes in a six-pin DIP and is expected to sell for $2.50 to $3.50 in small OEM quantities. And with no mechanical parts, this SSR could last through more than 50-billion operations.



Opto+photo combination

The key to the OFM-1A's impressive numbers is that it's the first device to combine optocoupling with photovoltaics and power-MOS technology. Unlike bipolar-based solid-state devices, the OFM-1A can draw current-source capabilities from DMOS that can be harnessed to make a more effective switch. In addition, the absence of Beta-multiplication, or majority-carrier effects, as in bipolar, permits the device to operate as a fixed low impedance, even at very low load voltages and currents. Bipolar devices, in contrast, exhibit significant Beta-multiplied leakage currents under high-temperature and high-voltage conditions, as well as significant impedance variations with small loads. MOS power devices, moreover, offer current flow with minimal on-resistance and leakage currents. On-resistance for many MOS power devices is less than 0.5 Ω, with no current leakage in the off-state.

Because the dual gates of the DMOS devices (Fig. 2) in the OFM-1A are voltage-sensing, the device requires a voltage generator. This voltage is created by a summing arrangement of photovoltaics: 16 diodes, each generating about 0.55 V, produce a 9-V potential. A monolithic 0.040 x 0.080-in. chip containing 32 diodes provides all the power required to drive the dual gates.

Light pipe isolates circuits

As Fig. 3 indicates, a "light pipe" consisting of an optically clear resin forms a fiber-optic link with a custom-made, high-brightness GaAlAs LED at the control circuit, and the photovoltaic voltage generators. Coupling efficiency through the pipe is better than 70%, while isolation between control and load circuits is on the order of 5000 to 10,000 V. The arrangement offers another important advantage: Capacitive coupling between input and output circuit is reduced to less than 0.5 pF.

Not surprisingly, the fast switching speeds and high isolation of the OFM-1A and subsequent OptoMOS members should have the greatest impact in those application areas now serviced by reed relays and other types of optocouplers—notably automatic test equipment. In this, the biggest application area for reed relays, the reeds are used to switch a wide range of currents and voltages repetitively onto an IC device from a computer-controlled tester, which performs dozens of tests each second. But while reeds offer low operating power, relatively high speed and small size, they cannot offer the operating life, replacement costs and switching speeds promised by the OptoMOS family.

Analog-I/O systems used for data acquisition, another area in which reed relays have been preferred, could also make good use of the new SSRs. In many of the I/O systems manufactured by Analog Devices, Datel, Burr-Brown, IBM and others, a flying-capacitor circuit is used to switch a low-level signal into the input of the signal-processing module. That is, the input signal first charges a capacitor, which is totally isolated from the input amplifier or signal conditioner. At specified frequencies, the capacitor is switched out of the signal input circuit, and into the amplifier. In this way, the discharging capacitor applies a facsimile of the input signal to the amplifier, and the input signal and amplifier lines are totally isolated from each other.

While reeds have been used to good advantage here, they are once again limited by relatively slow switching speeds. But not only will the OptoMOS devices provide higher switching speeds and bounce-free operation, they also will provide an easy 2500-V isolation between signal and input module while taking up less real estate on the analog-I/O board.

What's more, because of their high current and voltage-handling capabilities, the OptoMOS devices can easily replace other types of optocouplers in telecommunications applications handling 48-V, dc central-office voltages and 100-V, 20-Hz ringing voltages, as well as power-line monitors and industrial control systems. MOS devices, in fact, are not troubled by the bipolar offset that frequently limits the use of conventional SSRs.

Triac replacements

Because the dual-gate construction allows them to handle ac as well as dc currents, the OptoMOS devices could be used successfully as triac replacements in appliances, industrial controls and line-voltage switchers. Triacs are effective in phase-control applications like light dimmers and motor-speed controls because of their ability to latch-on with a short trigger pulse. However, they are also subject to latch-ons from stray pulses. In this situation, internal leakages due to high temperatures, line transients or commutating dv/dt conditions under an inductive load condition can cause the triac to latch-on and maintain its "on" state even in the absence of a control signal.

The OptoMOS devices, in contrast, will not latch inadvertently. In power-line switching, for example, a line transient will not latch the MOS devices, as it would triacs. An OptoMOS device, here, would function more like a mechanical relay than a regenerative solid-state device.

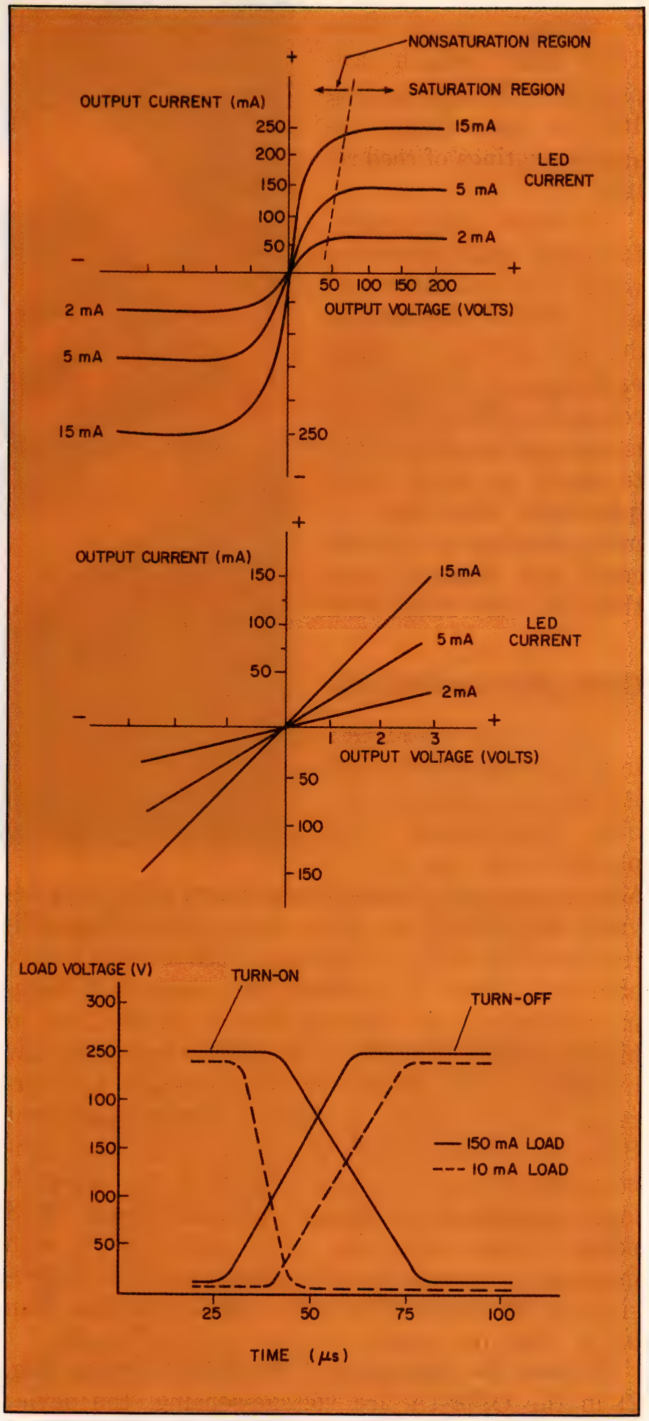
Another important consideration in comparing triacs with OptoMOS devices involves the zero-crossing effect in solid-state relays. In most line drivers, the output switch (a triac or pair of SCRs) is allowed to turn on only when the ac load voltage crosses the zero axis. With resistive loads, the device switches on as the current crosses zero, effectively eliminating RFI bursts and easing the device into an "on" state with a current buildup.

With inductive loads, however, current and voltage can be out-of-phase by as much as 90°. A zero-crossing relay, here, would trigger a turn-on at minimum voltage, but at maximum current. Applications involving motors and transformers of known power factor, as a result, would have to be run with special circuits designed to trigger the triac at a peak line voltage to ensure zero current switching.

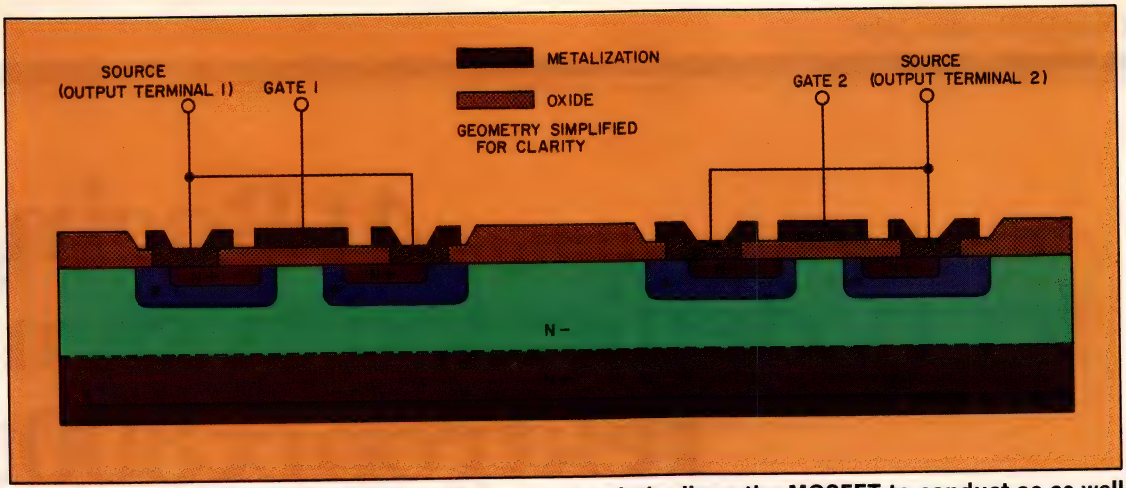
In microwave-oven controls—a microprocessor is used to synchronize and generate the trigger pulse.

Faster turn-on

For most low-power factor applications involving line switching, however, a random turn-on solid-state relay provides the most sensible alternative to the zero-crossing triac. Most photocell optocouplers provide low-cost random-turn-on switching, but require more than a millisecond to respond to a microprocessor or logic-gate signal. Instead of designing-in various driver-circuit configurations to obtain fast, midcycle (max voltage, min current) turn-on, the OptoMOS devices could be used for faster turn-on times, and for dv/dt-immune triac driving well above the temperature limits of the triac itself. Or, for load currents under 2 A, the OptoMOS devices could handle the ac load directly.



1. MOS devices provide many characteristics useful in solid-state relays. The saturation current of the OptoMOS coupler (top) is independent of load voltage, though the current-voltage curve is extremely linear before saturation (middle). Significantly, the turn-on/turn-off times are very short (bottom) under a variety of load currents.



2. The dual-gate structure of the OptoMOS current switch allows the MOSFET to conduct ac as well as dc. Photovoltaic cells are summed to provide the needed gate drive.

One other application area that looks promising is to use OptoMOS devices to enhance or reinforce electromechanical relays.

In one case, a combination lamp and inductive load is switched at several cycles per minute. To make full use of each relay type, the devices are sequenced so that the OptoMOS part performs the switching functions, while the electromechanical relay actually carries the load. As a rule, the mechanical device does not like to turn on lamp loads or turn off inductive loads, while the OptoMOS device feels comfortable with switching operations but cannot remain on with high current for very long without introducing heat sink considerations.

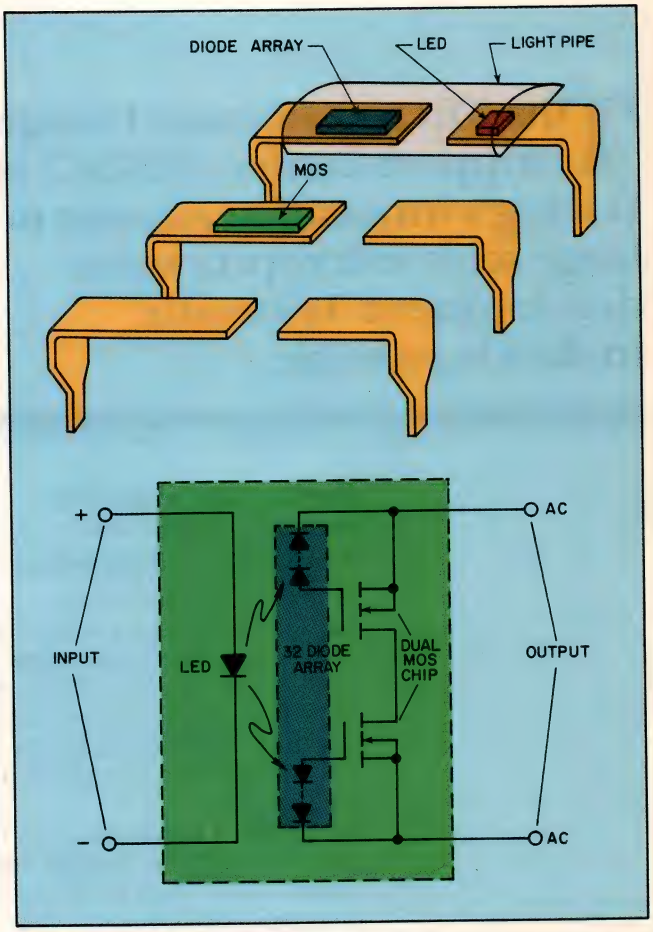
Programmed turn-off

A device like the OFM-1A can be made available with turn-off time programmed internally to be greater than 1 ms, adequate to ensure that the mechanical contacts are already functioning.

With an OptoMOS-enhanced relay circuit, in sum, the Optocoupler actually completes the switching, while the electromechanical relay actually carries most of the current. The devices are sequenced so that the OptoMOS part turns on before the mechanical relay, and turns off after the relay.

With this OptoMOS enhancement, a relay could be made to last nearly as long as its theoretical mechanical lifetime, even with high-voltage incandescent, capacitive or inductive loads. Note also that a triac or triac-output SSR could not be used for this application. A triac can only turn off at the next zero crossing of the current sine wave. Whenever a turn-off signal occurs within a millisecond or two of the zero crossing, the triac would unlatch before the contacts open, thereby precluding protection.■■

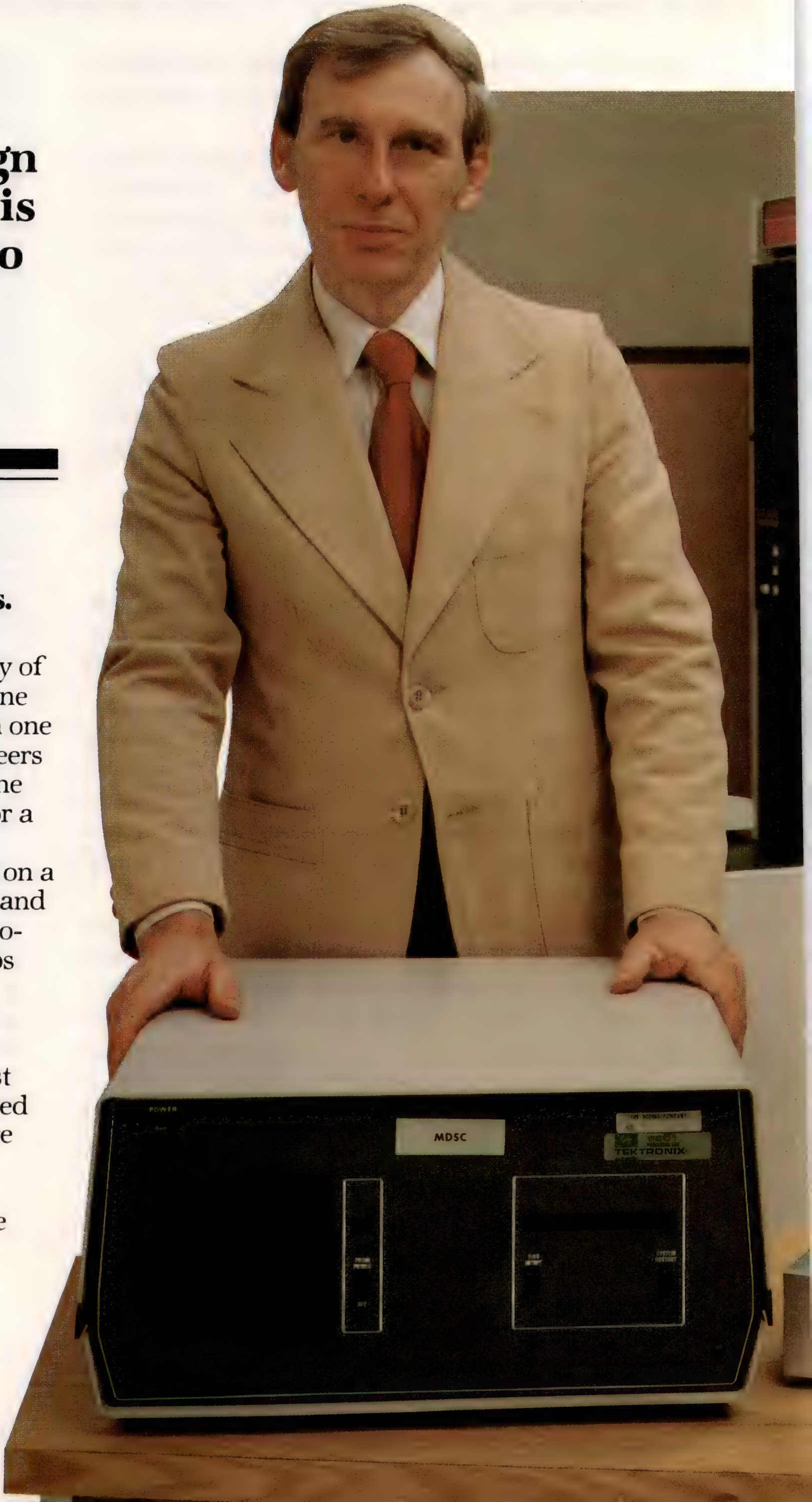
How useful?	**Circle No.**
Immediate design application	**541**
Within the next year	**542**
Not applicable	**543**



3. Three chips make up the OptoMOS coupler: an LED input, a photovoltaic diode array and the MOS switcher. The LED and voltage generator are connected by an optically transparent resin, and the lead frame acts as an additional heat sink for the MOS device.

At Boeing forty dedicated systems Tektronix 8001s

The Microprocessor Design Support Center (MDSC) is Boeing's innovative answer to large scale microprocessor development. Tektronix makes it possible.



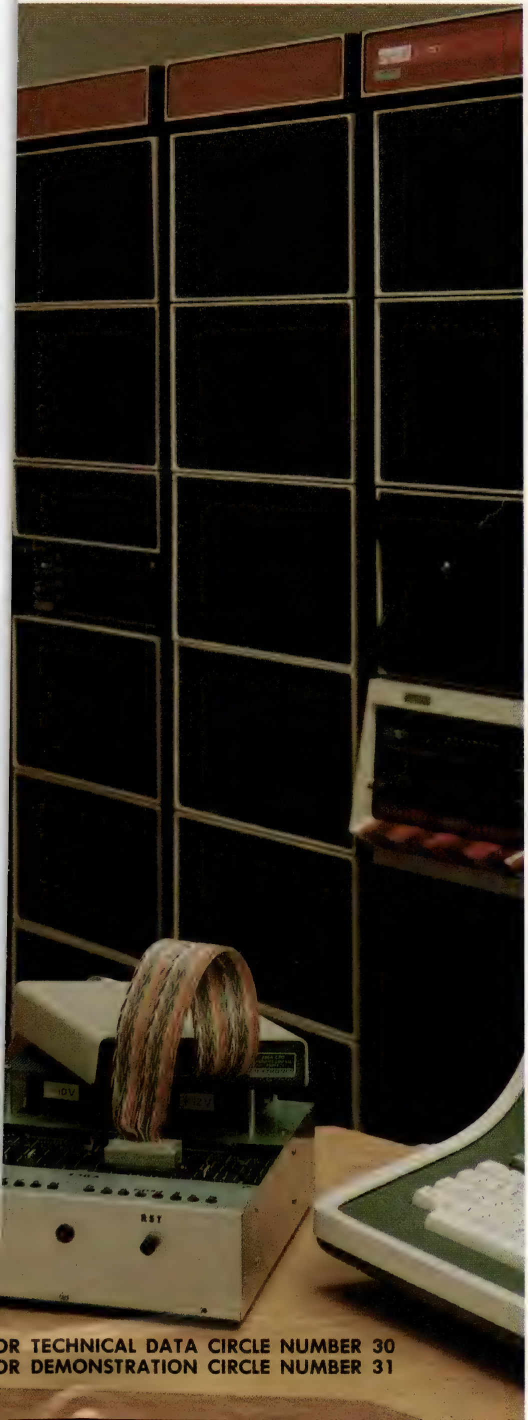
Boeing now supports over 120 engineers working on 35 projects.

Before the creation of the MDSC, Boeing used a variety of different vendors' stand-alone development systems. Each one supported only three engineers at a time, and more than one system was often needed for a single project.

Now, software is developed on a DEC PDP 11/70® computer and transferred to six 8001 Microprocessor Development Labs for in-circuit emulation, debugging, and prototype integration.

By using one multi-user host computer with six distributed 8001s, Boeing is able to more efficiently support 120 engineers. With 8001s costing half as much as stand-alone development systems.

couldn't do what six are doing.



Development isn't limited by dedicated, single-vendor systems.

The 8001 supports every microprocessor Boeing uses, so, they're free to choose the right microprocessor for the job. And whether it's the Texas Instruments TMS9900, Zilog Z80A, Intel 8048, Motorola 6800, RCA 1802, or 14 others — the 8001 emulates it. Tek's multi-vendor support doesn't lock Boeing into one vendor's family of microprocessors.

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Ability is of little account without opportunity.

—Napoleon

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Dual-channel electrometer/DMM measures ratios or differences

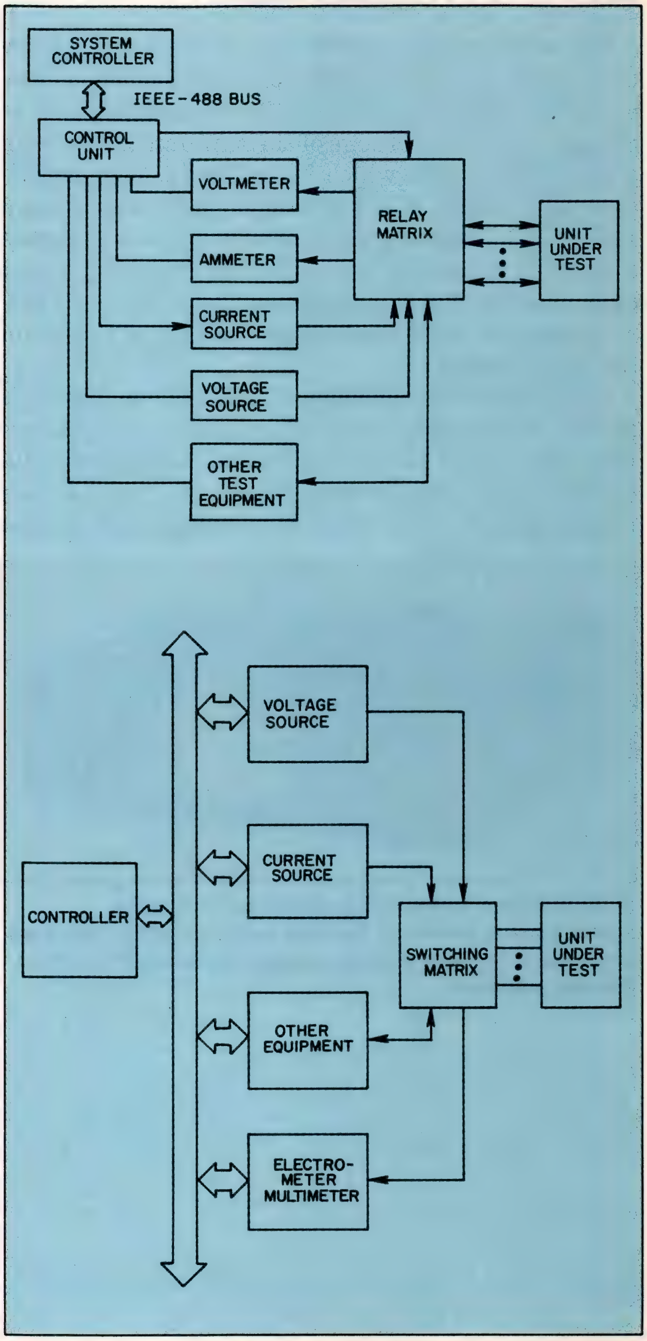
The first dual-channel electrometer/multimeter brings exceptional sensitivity, resolution, accuracy and precision to delicate measurements. With its many operator features and easy interfacing to an IEEE-488 bus, the model 619 electrometer/multimeter does more than replace two pieces of hardware. Its two channels are completely isolated and independently programmable: The ratio or difference of two variables, one from each channel, can be ascertained at the push of a button. One channel measures, say, volts while the second measures current; then the instrument's microprocessor does calculations with parameters from both.

For example, the h_{fe} of a bipolar transistor is determined by measuring both base and collector currents and then taking a simple ratio of the two. One channel of the 619 is set to measure current; its probe is attached to the base of the transistor. The second channel, also set to measure current, derives its input from the collector of the transistor. When the ratio button on the instrument is pressed, the value of h_{fe} is automatically calculated and displayed.

With the meter attached to the IEEE-488 bus, the controller of a system takes over the ratio and difference calculations. The 619 is then relegated to the conventional job of collecting the readings. All front-panel controls, except ratio and difference, are GPIB programmable, as are many data-formatting parameters.

Another benefit of the dual channels is in building systems to measure voltages from high-impedance sources and simultaneously measure very low currents. Semiconductor testing is an example: Voltage-source impedances can reach 10^{10} Ω, while currents in the range of 1 pA are common. Previous systems for measuring these parameters (Fig. 1a) required an electrometer system—that is, a high-impedence unity-gain amplifier providing a low-impedance analog output to a high-speed, high-resolution digital voltmeter (DVM). The DVM, in turn, needed control electronics to tie into the IEEE-488 bus. This combination, which costs about $5000, is replaced by just one channel of a 619 meter.

Bob Erdman, Product Manager, **Phil D'Angelo,** Project Manager, **Bob Miles,** Design Engineer, Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139.



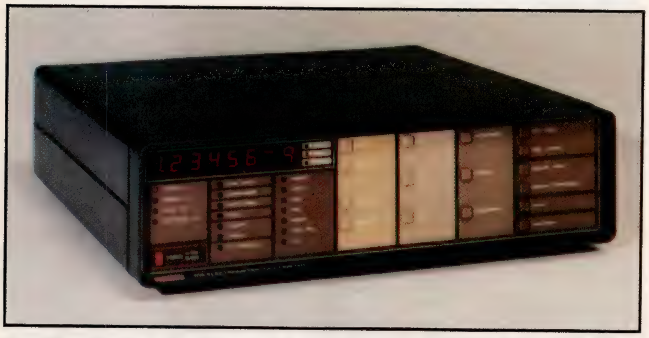
1. In the past, semiconductor tests-systems required a picoammeter and two other boxes (labeled voltmeter here) to get high-impedance and high-speed measurements, as well as control electronics to tie into the IEEE-488 bus (a). The new meter eliminates all three boxes and ties directly onto the bus (b).

For reading the current, the older system required a picoammeter. Although more than adequate for the task, the picoammeter had some drawbacks. It added a third box to the system and another \$3000 to the cost, and it required interface electronics to get on the bus. Thus, the cost for just the current and voltage measurement functions was approximately \$10,000. When both channels of the new electrometer are used, the system costs less than half the amount of the older system, needs only one box and is directly interfaceable to the IEEE-488 bus (Fig. 1b).

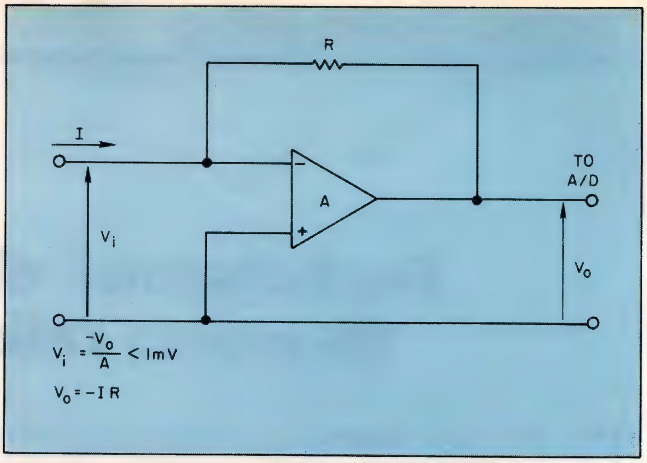
What the 619's capability means

The most sensitive DMMs can measure only as low as 1 μA to 10 nA—the 619 can detect levels as low as 10^{-14}A. Resolution (the smallest detectable level of change) on the 1-nA range of the new unit can go from a 4-1/2 digit mode, which has a 100-fA least-significant digit (LSD), to a 5-1/2 digit mode, which has a 10-fA LSD. Accuracy (how closely a meter indicates a quantity compared to an absolute standard) is just as impressive: 0.01% + 1 digit on the 2-V range; 0.15% + 4 digits on the 200-nA range; and 1% + 1 digit on the 20-GΩ range.

Input resistance on volts (1 μV LSD to 200 V) is 20 TΩ. Resistances from 10 mΩ LSD to 2 TΩ are read directly. In the filtered mode, response to 0.1% of final value is 5 ms on volts, and the 20-μA and higher ranges, and 50 ms on the 2-nA through 2-μA ranges.



2. The digital electronics in the Model 619 meter automatically performs internal zero correction, initiated when the ZERO CHECK and ZERO CORRECT buttons on the front panel are pressed.



3. The feedback-ammeter configuration—traditionally used in electrometers and picoammeters—produces a low input-voltage burden. The result is a reduction in errors and in the system time constants.

Indeed, the 619 combines the features of both traditional analog electrometers and digital multimeters. But it is superior to both in resolution, precision (or repeatability) and accuracy.

Analog-meter displays are subject to operator interpretation, and most conventional digital low-current instruments have fewer readout digits—typically 3-1/2, compared to the 5-1/2 digits of the 619. Thus, with the older systems, detecting a 10 or 100-parts-per-million (ppm) change in a variable is difficult, if not impossible.

Feedback minimizes errors

An important contributor to the 619's system performance is a feedback ammeter circuit in which a current-sensing resistor is connected from the output to the negative input of a high-impedance, high-gain amplifier (Fig. 3). The positive input is grounded. The circuit provides the a/d converter with a low-impedance voltage proportional to input current. It also provides a much lower input voltage (voltage burden) than those DMMs using a shunt ammeter approach. This minimizes both the voltage-drop errors across the ammeter and the charge stored in the system cabling.

Up to 5000-pF source capacity may be used with the 619. A DMM with 200-mV voltage burden would require 1000 pC (picocoulombs) to charge this cable capacity; the 619 requires only a maximum of 5 pC because of its lower input voltage. Thus the feedback ammeter configuration significantly improves system time constants.

In high-impedance voltage measurements, a similar improvement can be made by driving the inner shield of a triaxial input cable with a voltage essentially equal to the input voltage, using a guarded input-adapter accessory. This reduces effective cable capacity to a few pF, even with 5000 pF system cabling capacity.

Some features of the 619 are not commonly found on conventional electrometers: zero correction, baseline control and autoranging.

Automatic zero correction is performed by the 619's digital portion. It is initiated by actuating ZERO CHECK, which places the electrometer input circuitry in a condition to measure only the input offset voltage error. Actuating ZERO CORRECT initiates a measurement and computation sequence that corrects future readings for input offset voltage error within the selected function.

The baseline control feature extends the zero-correction concept externally. With it, an offset signal can be deliberately inserted to compensate for background signals generated by connection hardware between the meter and the signal source. BASELINE STORE determines this background level and stores it in the instrument's digital electronics. Thereafter, when BASELINE SUPPRESSION is activated, this stored quantity is automatically subtracted from the level being measured.

LISTEN 6a	Address 619 Channel A; command to listen. (Primary address 6, secondary a)
F1R2T1S1X	Set Channel A to 20-nA range, one-shot trigger on talk, one-line period integration.
LISTEN 6b	Address 619 Channel B; command to listen.
F0R1T1S1X	Set Channel B to 200-mV range, one-shot trigger on talk, one-line period integration.
TALK 6b	Trigger A reading on Channel B.
NDCV+09.125E-03	Voltage value (data output).
TALK 6a	Trigger A reading on Channel A.
NDCA+12.457E-09	Current value (data output).

4. The sample program obtains a voltage reading and then a current reading at an independent point.

The capability is also useful in measuring with respect to a reference, for instance, phototube dark current.

Finally, although autoranging is an operator convenience commonly found on DMMs, most electrometers offer only a down-range capability. In the 619, autoranging occurs in both directions, up and down.

The meter, the bus and the IEEE

The 619 also eases the job of interfacing to and operating with an IEEE-488 bus system. Every function of the meter can be accessed by commands of just two ASCII characters, a letter followed by a number. For example, to command the unit to initiate its volts function, a system issues an F0 command. An F1 gets the amps function, and F2 calls for the ohms function.

The command string needed to configure the system is, therefore, small. Once the functions of the instrument are completely configured, the configuration can be changed by as little as one item at a time, along with the appropriate two-character command.

In the sample program in Fig. 4, the instrument is equipped with both channels. Channel A measures the current while channel B reads the voltage. The first LISTEN command instructs the instrument's A channel to receive a bus transmission. Thereafter, the command F1R2T1S1X (reading from left to right) tells the channel to measure current, F1; to configure for the 20-nA range, range, R2; to produce a one-shot trigger on receiving the next Talk command, T1; and to take its reading at 16.67 ms integration time, S1. Finally, the concluding letter X in the command string tells the instrument to execute the string. Note that 10 different reading rates may be selected from 18 ms (3-1/2-digit precision) to an average of 32, 5-1/2-digit readings (6.75 s).

Next, in the program, the third and fourth commands configure channel B. Upon the TALK command, channel B takes a reading. Following the command is the meter's response, NDCV+09.125E-03. The letter N specifies a normal reading; DCV states the type of reading (dc voltage); +09.125 gives the value of voltage detected; and E-03 is the exponent.

Because the system can buffer up to 50 readings, it unburdens the system controller from having to service the instrument after each reading. The meter has two programmable data terminator capability. The instrument can also produce a (CR) (LF) or (LF) (CR) terminators or any ASCII character other than one used to program the unit as a terminator. Thus the 619 meter will fit the requirements of any system configuration in which it might be used.■■

How useful?	**Circle No.**
Immediate design application	**544**
Within the next year	**545**
Not applicable	**546**

Rockwell International is more than a builder of avionics for most of America's airliners.

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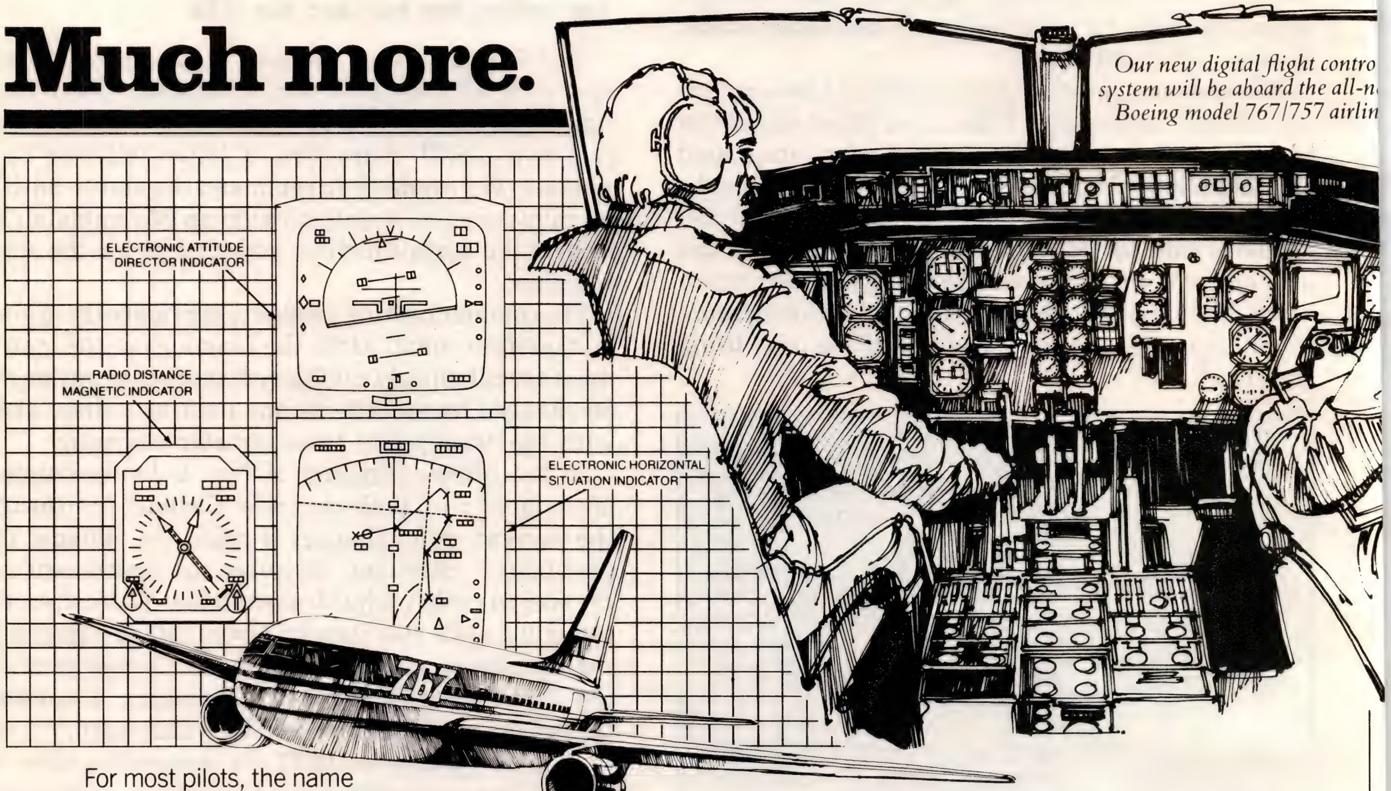
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Our new digital flight contro system will be aboard the all-n Boeing model 767/757 airlin

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Rockwell International is a major multi-industry company applying advanced technology to a wide range of products — in automotive, aerospace, electronics and general industries. Following are some examples of our balanced diversification.

Electronics.

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Our position as one of the world's leading suppliers of avionics — communications, navigation and flight control equipment — reflects only one of our electronic businesses.

We also make microelectronic systems and devices, broadcast equipment, and missile guidance and control systems. And we manufacture and install telecommunications systems, including both digital and analog microwave systems, for businesses and governments worldwide.

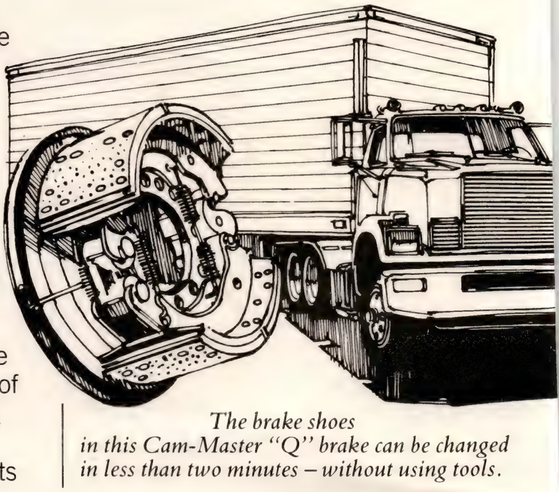
Automotive.

(Sales, fiscal 1979: $1.8 billion.)

One-half of the highway tandem tractors in North America are equipped with Rockwell axles — and more than half of the heavy-duty trucks stop with Rockwell brakes. We're also a major supplier of drivelines, steel and styled aluminum wheels, mechanical devices, castings, stainless steel wheel covers and other components for trucks, trailers, buses, vans and passenger cars.

Our Cam-Master® "Q"™ is the latest in the most widely used series of heavy-duty air brakes in the trucking industry. The "Q" is known as "the no-sweat, no-tools brake," because its special design permits changing brake shoes without tools, in less than two minutes.

Rockwell's extensive product line of mechanical, hydraulic, cam and wedge brakes is the result of over a half-century of design, engineering and manufacturing experience. Our most popular brake designs have been proved on and off the highway in literally billions of miles on the job.



The brake shoes in this Cam-Master "Q" brake can be changed in less than two minutes – without using tools.

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(Sales, fiscal 1979: $1.6 billion.)

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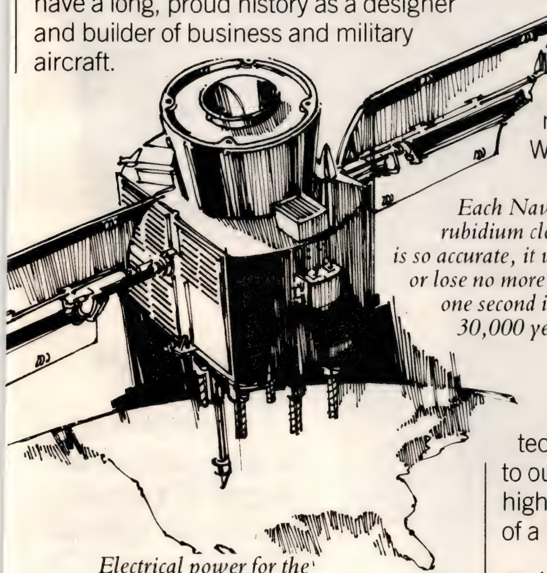

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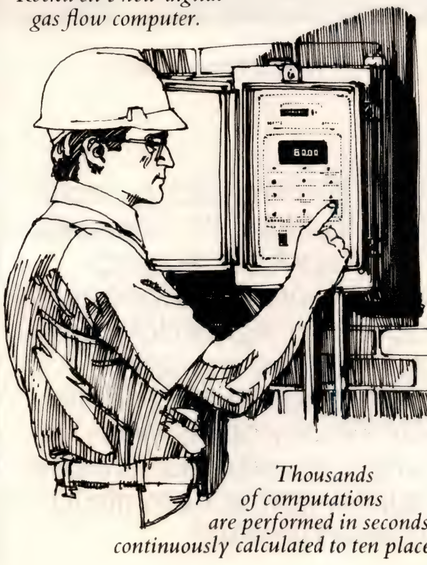

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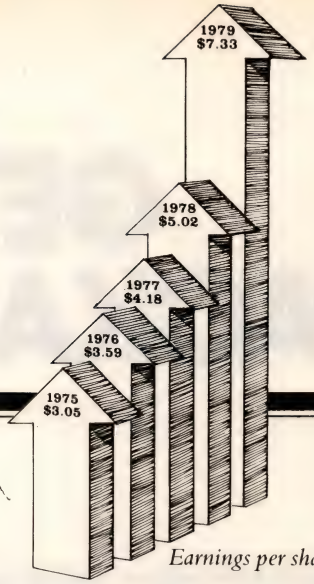

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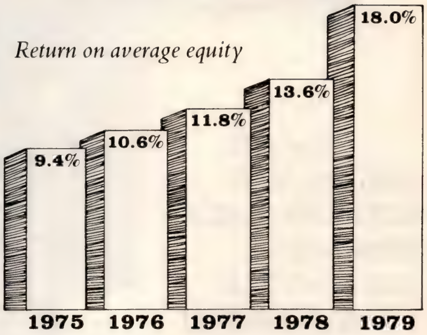
Return on average equity



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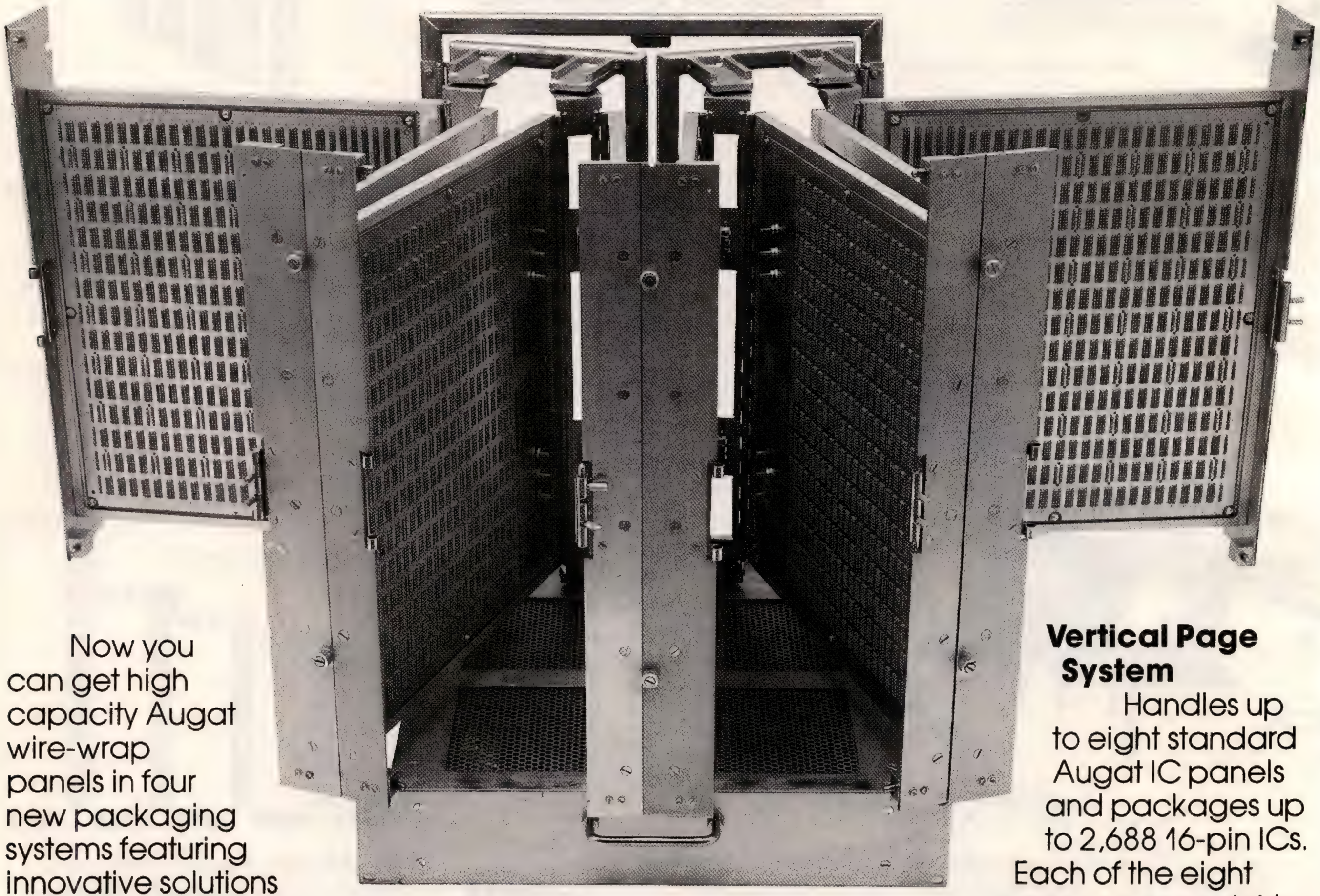

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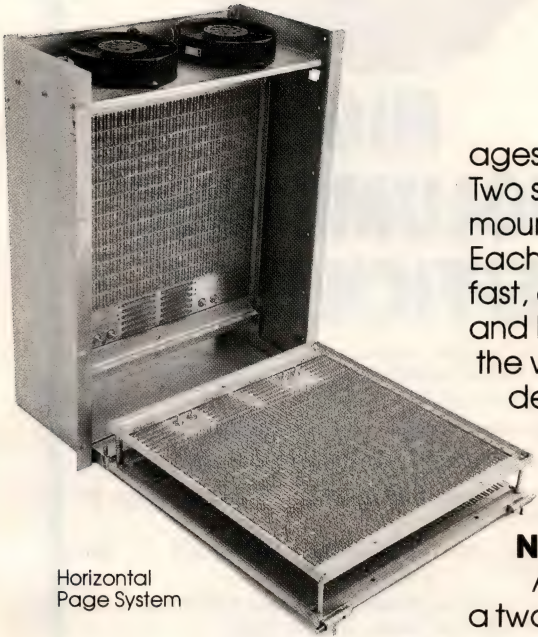
Horizontal Page System

stitch-weld; and single, double and triple width boards in the same enclosure. Choose either a continuous backplane or three separate backplanes to provide the different voltages and grounds needed to mix analog and digital boards. All are assembled with 96-pin I/O connectors. Flexible spacing lets you use up to four wire-wrap boards (1.2″ spacing) or 7 stitch-weld boards (.6″ spacing) or a combination of the two. Guide separators let you mix different width boards. Fans are optional.

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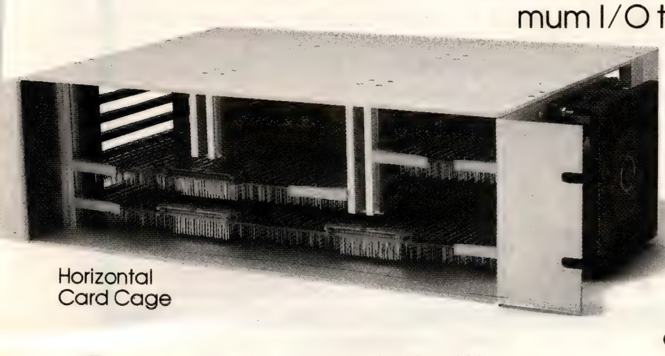
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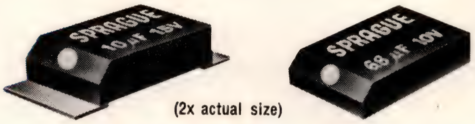

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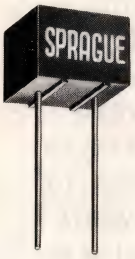

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CIRCLE NUMBER 38

BIMOS op amps more than replace BIFETs in low-cost instruments and audio gear

The CA080 op amps from RCA offer much more than just BIMOS versions of Texas Instruments' TL080-series BIFETS—they offer lower input bias and offset currents, higher input impedances, and wider bandwidths than their BIFET counterparts and other pin-compatible op amps. Intended for low-cost test instruments, data-acquisition and audio amplifiers, the CA080 series features both PMOS and bipolar technology on a monolithic chip housed in an eight-lead DIP or TO-5 case. So, along with impressive specs comes an extremely versatile op-amp configuration.

The front end of the amp consists of MOSFETs in a differential-input configuration, which provides the unusually high input impedances—typically on the order of 1.5×10^{12} Ω—thereby minimizing loading effects. Low power consumption, 42 mW for a single amplifier channel, makes the op amp ideal for portable equipment. The input bias current is less than 15 pA. The input offset current is typically 5 pA; the circuit provides pinouts for external offset-voltage null-compensation circuitry (CA080, CA081, CA083).

Besides low power consumption, the CA080 series provides high gain, wide bandwidth and low input noise voltage. Unity-gain bandwidth is close to 5 MHz, typical open-loop gain is 106 dB, and slew rate is on the order of 13 V/μs. Noise is less than 40 nV/$\sqrt{\text{Hz}}$ at 1 kHz and 38 nV/$\sqrt{\text{Hz}}$ at 10 kHz. Common-mode rejection is typically 86 dB. The device is easily capable of generating a ±25-V output-voltage swing—enough to drive a large variety of power-output devices. To see how well the BIMOS devices stack up against their BIFET counterparts, see "BIMOS vs BIFET."

There are four versions of the CA080 series: the CA080 externally phase-compensated single op amp, CA081 internally phase-compensated single op amp and the CA082 and CA083 internally phase-compensated dual op amps.

Wide range of applications

Pin compatibility with the Texas Instruments TL080 series and a number of other popular op amps aside, the BIMOS devices are ideal for many different application areas, including the front end of ac voltmeters, audio preamplifiers, notch filters and low-current amplification circuits. The ultrahigh impedance characteristic of the CA081 is especially useful in ac-voltmeter applications (Fig. 1), where the meter must have minimal loading effect on the circuit being measured. Because of the CA081's wide bandwidth and fast slew rate, the meter operates up to 0.5 MHz. Because of the device's low input bias current, the use of the 22 MΩ resistors will not significantly affect the quiescent output voltage of the bootstrap input circuit. This input circuit minimizes loading of the circuit under test by providing approximately 22-MΩ input resistance and 15-pF input capacitance over this frequency range.

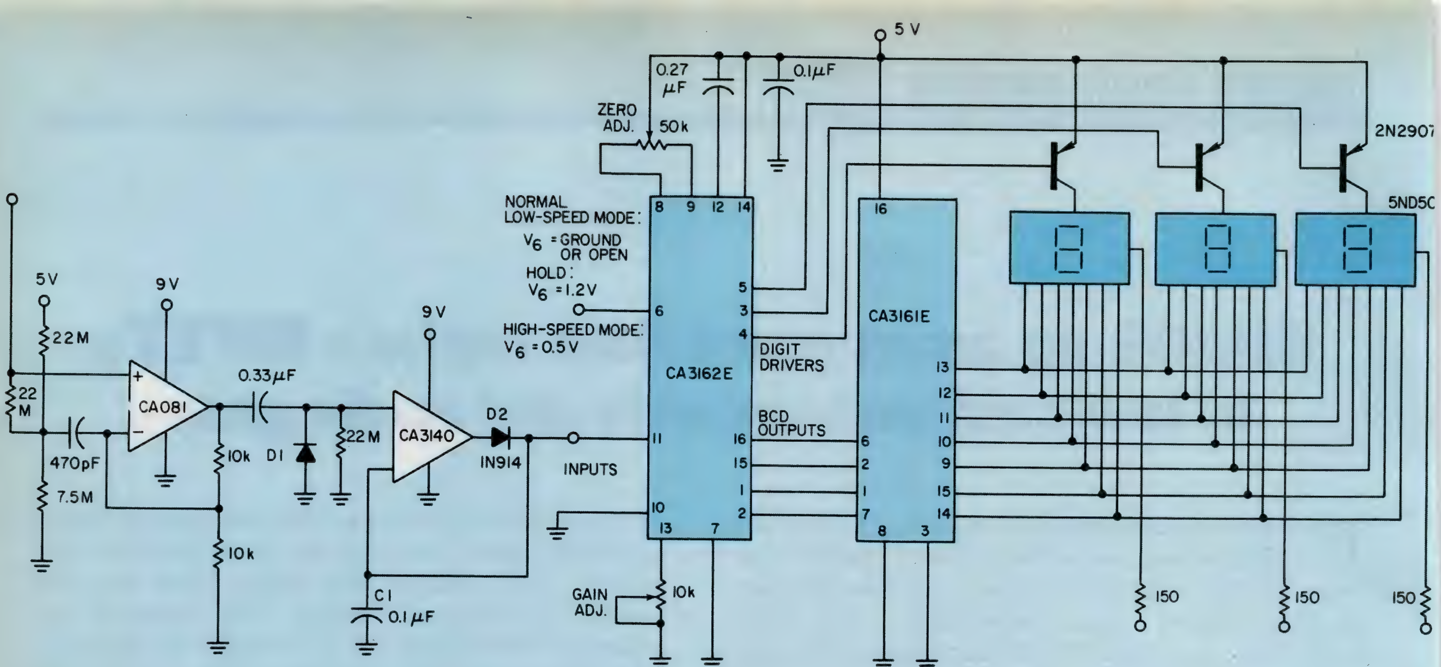
In addition, because of its very low bias currents, the CA081 is effective in making nanoampere mea-

BIMOS vs BIFET

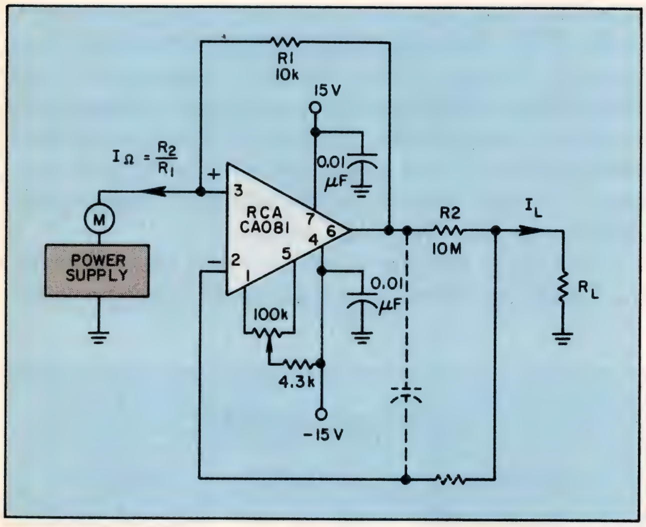
Specifications	TL080/081	CA080/081
Input bias current	400 pA max.	50 pA max.
Input offset current	200 pA max.	30 pA max.
Slew rate	13 V/μs	13 V/μs
Bandwidth	3 MHz	5 MHz
Noise at 1 kHz	25 nV/$\sqrt{\text{Hz}}$	40 nV/$\sqrt{\text{Hz}}$
Noise at 10 kHz	25 nV/$\sqrt{\text{Hz}}$	38 nV/$\sqrt{\text{Hz}}$
Input impedance	1×10^{12} Ω	1.5×10^{12} Ω

Note: all specs typical unless otherwise noted

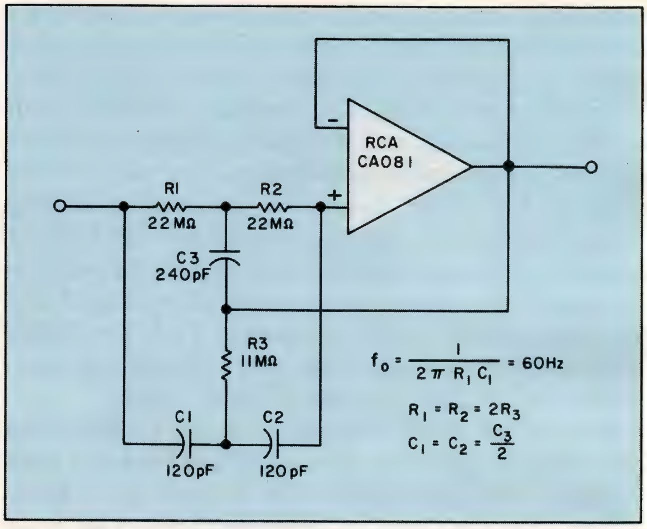
George M. Harayda, Applications Engineer, and **Thomas A. Chesek,** Market Analyst, Linear ICs, RCA, Solid State Division, Route 202, Somerville, NJ 08876.



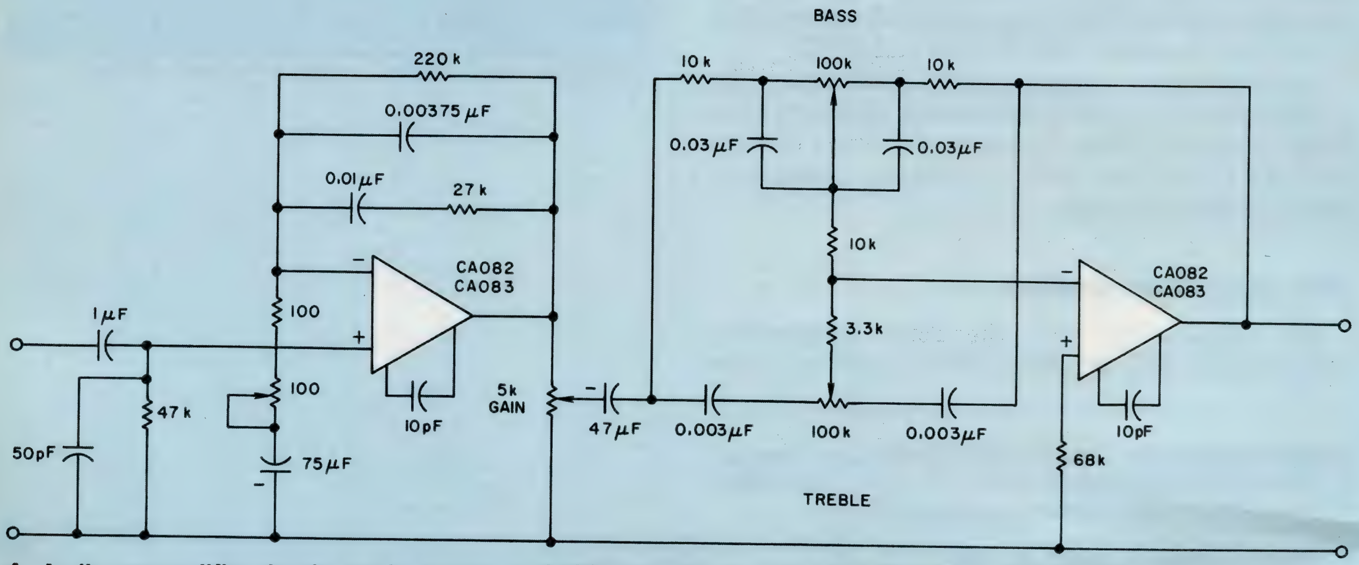
1. The ultrahigh impedance the CA081 encourages may require bootstrap protection.



2. Current-amplifier gain is controlled by the load resistance, R_L, and is a function of the R_2/R_1 ratio.



3. A high-Q notch filter is easy-to-accomplish with careful matching of the passive filter components.



4. Audio-preamplifier circuits can be constructed with high gain, low noise and distortion using dual op amps.

surements (Fig. 2). Here, the current gain is a function of the ratio of R_2/R_1. For the values shown, the current gain is 1000. Thus, if the load current is 100 nA, at the output of the current amplifier circuit, the meter reads 100 nA from the supply. This measurement technique can be applied in many low current measurement situations.

Note that the dotted components show a method of decoupling the circuit from the effects of high output-load capacitance, and eliminating the potential for oscillation in this circuit. Essentially, the high-frequency feed is provided by the capacitor, while the dotted series resistor decouples the load from the feedback loop.

High-Q notch filters

The low input bias current of the CA080 devices should suit them to another interesting application: high-Q notch filters. Because of the device's minimal input currents, large-value resistors can be used in the R-C filter network, minimizing the capacitance values required and decreasing the cost.

As Fig. 3 illustrates, the notch filter consists of both a low-pass filter network (R_1, R_2, C_3) and a high-pass filter (R_3, C_1, C_2) network. The values shown are for a center frequency of 60 Hz. The quality of the notch —the Q of the filter—is a function of how closely the components are matched.

The new BIMOS circuits should also prove quite amenable to audio preamp applications. Fig. 4 shows one channel of a stereo preamplifier, complete with RIAA phonoequalization, tone controls, and enough gain to drive a majority of commercial power amplifiers. The total harmonic distortion of the CA080 series when driven to produce a 6-V output, is less than 0.06% in the frequency range from 100 Hz to 100 kHz, and less than 0.035% in the audio-frequency range from 150 Hz to 40 kHz.

In the circuit shown, the 220-kΩ resistor, the 0.00375-μF capacitor, the 27-kΩ resistor, and the 0.01-μF capacitor network provide phono equalization in the negative-feedback loop of the first amplification stage. A simplified tone control circuit, in addition, is provided by 100-kΩ pots, and other R-C filters in the negative feedback loop of the second amplification stage. The 5-kΩ pot across the output of the first amplification stage controls the volume of the preamp.

For the CA082, the positive supply voltage is connected at pin 8, while the negative supply voltage is connected at pin 4. This applies to both the TO-5 and DIP-packaged versions. The DIP-packaged CA083, however, receives +V at pin 9 and -V at pin 4. ■■

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Immediate design application	**547**
Within the next year	**548**
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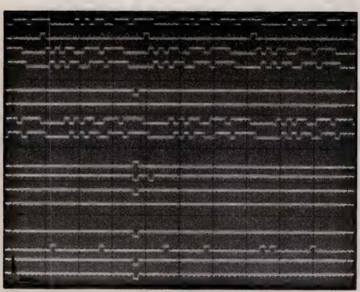

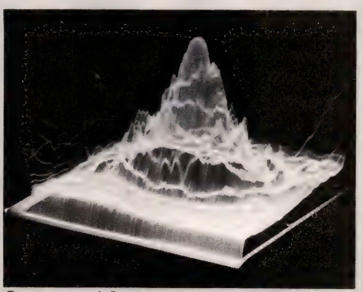

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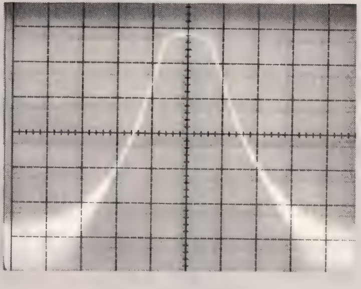

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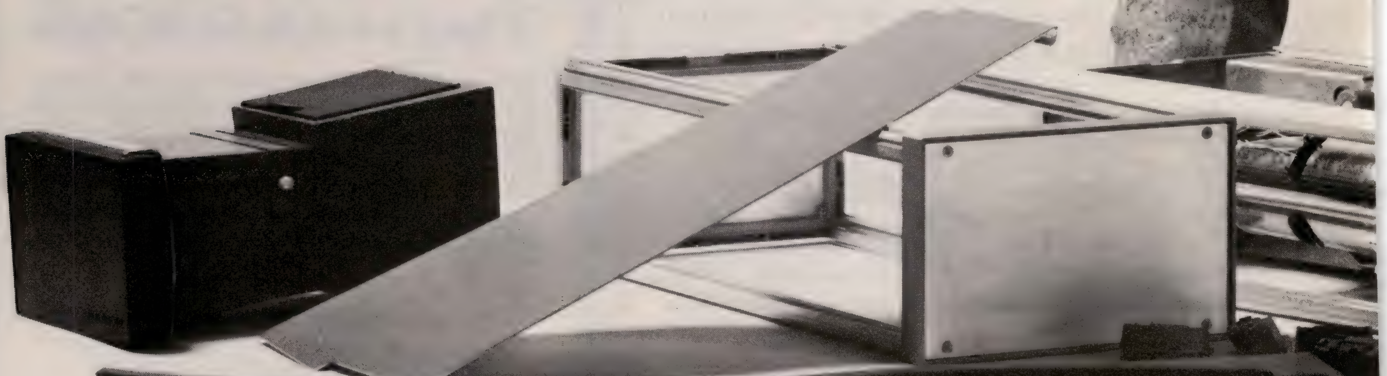

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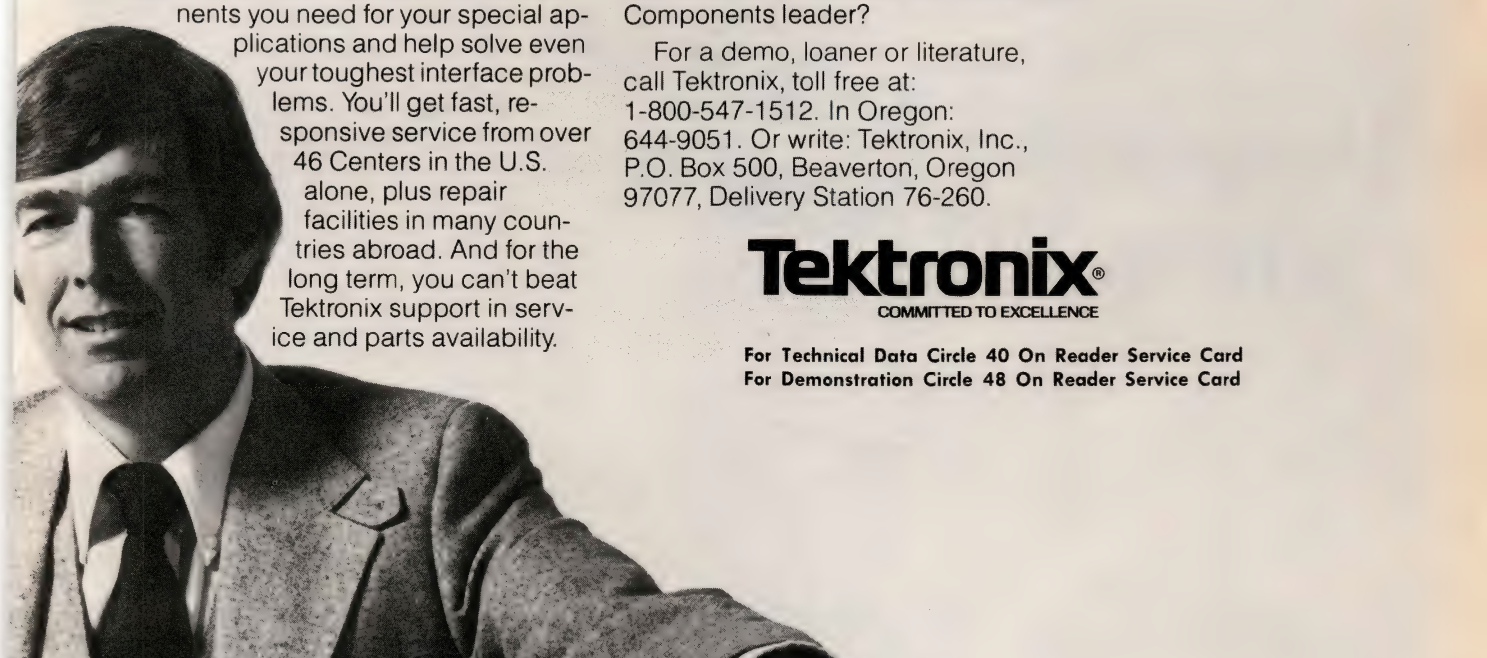

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CIRCLE NUMBER 41

For complete μP design, logic analyzers finish what development systems start

What a development system finds wrong during final system debugging, a logic analyzer can track down. Even development systems with logic-analysis capability can work only in the data domain. Signal timing relationships, so critical to final system performance, would go unchecked without logic analyzers.

Both devices have their own place during microprocessor development: The development system claims the software programming phase while the logic analyzer, with its timing-analysis capabilities, suits the hardware phase. The clash occurs during hardware/software system integration.

In many cases, the solution is simple: The devices complement each other, with the logic analyzer taking up where the development system—regardless of its capabilities—leaves off.

To see how this works, examine a typical case of an 8086-based prototype system that is storing information improperly. Although this problem is normally found at the hardware-design stage, both hardware and software techniques are used to isolate the problem.

Small-program emulation

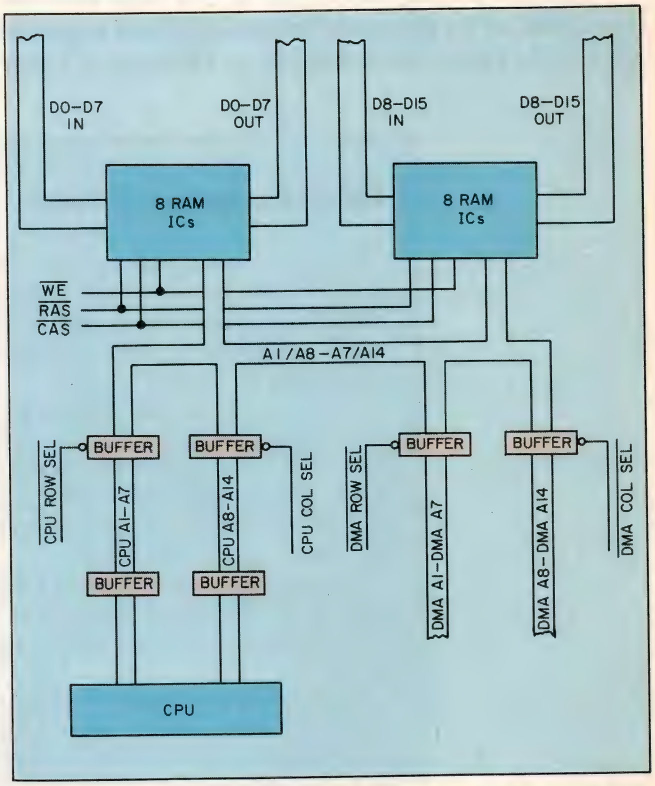
The prototype is a relatively complex 16-bit system with 32 kbytes of dual-port RAM, 32 kbytes of ROM, a first-in-first-out (FIFO) buffer implemented in TTL logic, a DMA controller and CRT interface circuitry. To test the RAM, the 8086 in-circuit emulator emulates a small diagnostic program that rotates a ONE bit through memory.

In the program, the processor writes to all memory locations and later reads back memory contents for comparison. If an error is found, the processor writes the data from the failing memory location to a memory-mapped port (location 71000_{10}). Each time a comparison produces no error, the processor writes the data to another port (location 70000_{10}). When the program in this example is run, all data are written to point 71000_{10}.

Obviously, the memory is not working at any location. Examining the faulty addresses with emulation techniques is of little value since all of the memory is failing. And while it can be assumed that the system has an inherent design error, the development system stops short of giving any detailed information of what it could be.

The crux of the matter is that this type of problem requires an examination of the timing relationships of the signals setting up the valid address for the memory. Also, as Fig. 1 shows, these signals are separated from the processor's bus by buffers.

A development system—even one with some logic-analysis capabilities—would be stopped by this problem. All development systems are limited to data-domain analyses, which prevents them from doing timing measurements. What's more, separating the memory from the μP by buffers, and the number of



1. To pin down the timing problems of an 8086-based system's memory, the 16-channel K-100D logic analyzer is connected to the critical memory-timing signals of $\overline{\text{RAS}}$, $\overline{\text{CAS}}$ and $\overline{\text{WE}}$ as well as the address and data lines.

Bob Lorentzen, Product Manager, Gould Biomation Division 4600 Old Ironsides Dr., Santa Clara, CA 95050.

channels involved, puts the problem beyond the limits of the development system.

The best analysis tool, in this case, is a logic analyzer with time-domain capabilities. And a logic analyzer with timing-measurement capabilities on eight or 16-channels could display many different timing signals simultaneously, so that critical relationships could be observed (an oscilloscope would limit analysis to one channel at a time.)

To examine the critical input signals to memory, the Biomation K-100D 16-channel, 100-MHz logic analyzer can be set up as follows:

Channel	Signal	Description
F	RAS	Row Address Select
E	CAS	Column Address Select
D	WE	Write Enable
C	DEN	Data Enable
B	A7/A14	Multiplexed address lines of dual-port memory
A	A6/A13	
9	A5/A12	
8	A4/A11	
7	A3/A10	
6	A2/A9	
5	A1/A8	
4	CPU Row Select	Selects whether CPU or DMA address
3	CPU Column Select	
2	DMA Row Select	
1	DMA Column Select	
0	Data in D7	Data going to RAM

The clock rate is set to 100 MHz so that a sample can be taken every 10 ns. This resolution is often necessary since many of the memory signals have pulses or timing differences of less than 100 ns (see "Watch the Timing Resolution"). The logic analyzer is enabled on the processor's reset signal and triggered on a write signal. It records the 16 channels in either direction of the trigger in its 1024-word memory. In this case the logic analyzer is set up to record 500 clocks of pretrigger and post-trigger information.

As seen in Fig. 2a, Write Enable ($\overline{WE}$), channel D, is active. The next step is to examine the timing relationship of the three critical control lines for the memory: $\overline{RAS}$ (channel F) $\overline{CAS}$ (channel E) and $\overline{WE}$ (channel D). Direct time measurements can be made by using the K-100D's two cursors (displayed as vertical bars) and time indicator in the lower right-hand corner. A pulse width can be measured by positioning the first cursor on the leading edge of a pulse and positioning the reference cursor on the trailing edge. Measuring $\overline{RAS}$ and $\overline{CAS}$ pulse widths in this way indicates they are within specification.

Timing is important

However, just as important as the pulse widths in this case are the timing relationships of $\overline{RAS}$, $\overline{CAS}$ and $\overline{WE}$. According to the manufacturer's timing diagram (Fig. 2b), $\overline{RAS}$ and $\overline{CAS}$ should go high at about the same time, which is not the case as shown in Fig. 2a. Looking further, the precharge time (t_{rp}) for $\overline{RAS}$ (channel F) seems short. The spec states a minimum $\overline{RAS}$ of 0.150 μs with no upward limit. The actual time, as measured by the logic analyzer in Fig. 2c, is 0.050 μs.

The problem is to increase the precharge time of $\overline{RAS}$ by using different system timing signals: the system timing signals set and reset the $\overline{RAS}$ J-K flip-flop ($\overline{Q}$ output). To help find a solution, the logic analyzer examines the $\overline{RAS}$ signal along with other available timing signals and the system 24-MHz clock. The analyzer is connected as follows:

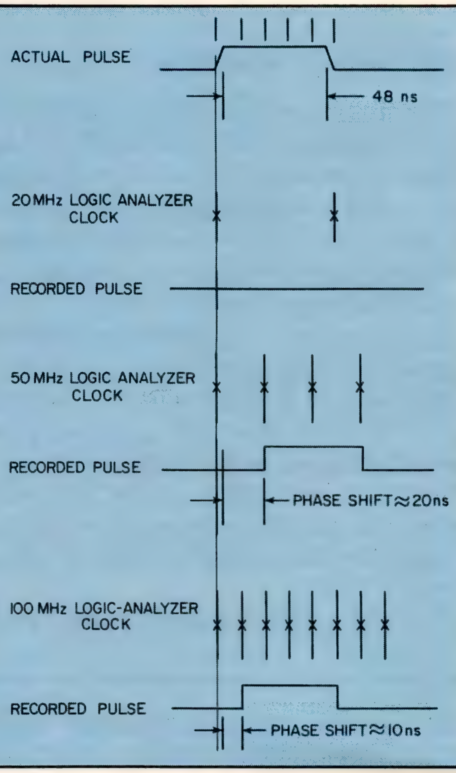
Watch the timing resolution

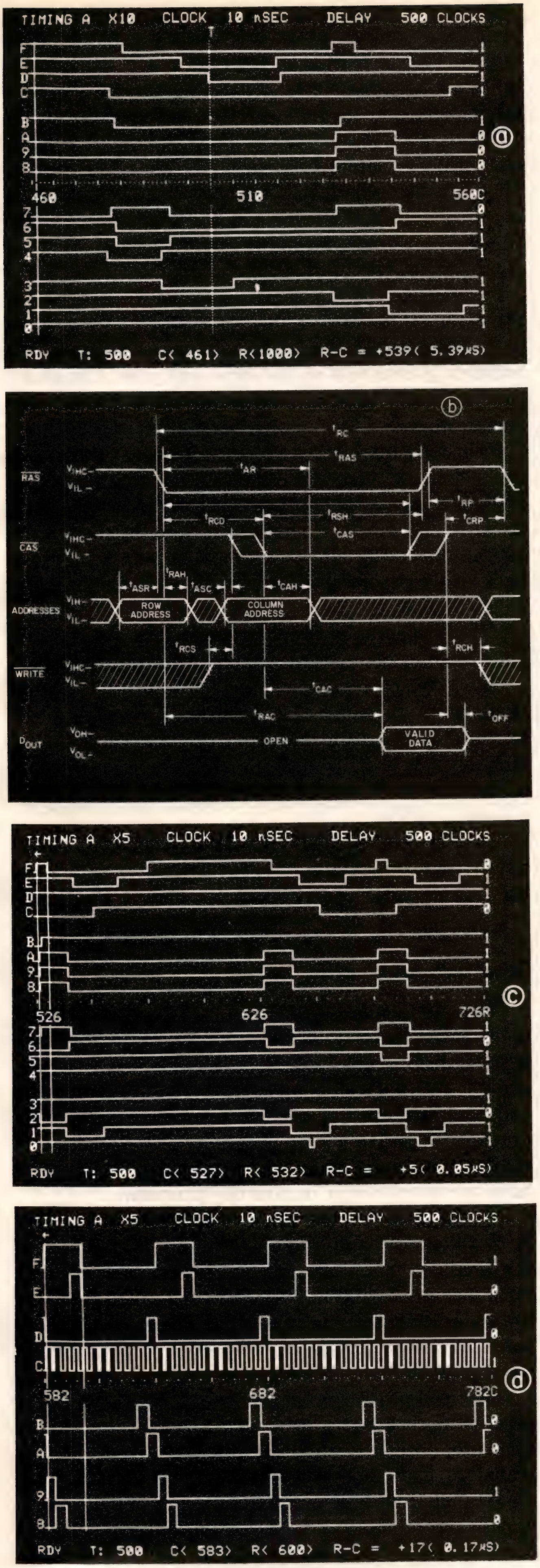
For good resolution, a pulse ideally should be sampled ten times by the logic analyzer's clock. Sampling at least four or five times can suffice provided the user is aware of potential measurement errors like phase shift.

A logic analyzer sampling at an insufficient rate could cause serious problems—like producing a display that looks good but is totally wrong (aliasing). With a low-resolution logic analyzer, however, there's no way of knowing this has occurred. But there is a way to avoid the situation.

The maximum recording rate a logic analyzer needs depends on the fastest signal to be measured. Many μP systems have critical timing signals of 50 ns or less.

The figure shows what a 50-ns pulse looks like when sampled with a 20-MHz, a 50-MHz, and a 100-MHz logic analyzer. Note that a logic analyzer could sample slowly enough to miss certain pulses. As the clock rate increases, the pulse will always be recorded and the phase shift minimized.




TIMING A X10 CLOCK 10 nSEC DELAY 500 CLOCKS
F
E
D
C
B
A
9
8
460
510
560C
7
6
5
4
3
2
1
0
RDY T: 500 C< 461> R<1000> R-C = +539(5.39µS)
a
b
RAS
CAS
ADDRESSES
WRITE
DOUT
VIHC
VIL
VIH
VOH
VOL
tRC
tRAS
tAR
tRP
tCRP
tRCD
tRSH
tCAS
tRAH
tASR
tASC
tCAH
ROW ADDRESS
COLUMN ADDRESS
tRCS
tRCH
tCAC
tRAC
tOFF
OPEN
VALID DATA
TIMING A X5 CLOCK 10 nSEC DELAY 500 CLOCKS
526
626
726R
c
RDY T: 500 C< 527> R< 532> R-C = +5(0.05µS)
TIMING A X5 CLOCK 10 nSEC DELAY 500 CLOCKS
582
682
782C
d
RDY T: 500 C< 583> R< 600> R-C = +17(0.17µS)

Channel	Signal	Description
F	RAS	Row-address select
E	Set	Sets RAS flip-flop
D	Reset	Resets RAS flip-flop
C	24-MHz Clock	Flip-flop clock
B	Count 1	
A	Count 2	
9	Count 3	
8	Count 4	

The precharge time pulse can be lengthened using one of the four displayed counts (Fig. 2d). This causes the RAS precharge time pulse to go high earlier. Count 2's falling edge (channel A) appears to provide the extra 0.120 µs necessary to meet or exceed the t_{tp}'s 0.150 µs minimum specification. Fig. 2d shows the result of using count 2, which yields a precharge time pulse of 0.17 µs. This pulse width is read directly from the logic analyzer's display (see the lower right-hand corner in Fig. 2d).

Although this problem probably would appear in the hardware design phase of the development cycle, both software and hardware analysis are needed to track it down. The diagnostic software program running under in-circuit emulation gives a quick go/no-go indication that something is wrong. With the logic analyzer, the error could be tracked down from there and ultimately fixed.

Hardware or software?

But what if it isn't obvious that the error is a hardware or software problem? This sort of predicament commonly crops up in the system-integration stage of a development cycle.

Say a 6800 microprocessor system is programmed to transfer a bit of status information to GPIB-related circuitry—but the status information is never received (Fig. 3). In-circuit emulation would help isolate the problem: With it, a breakpoint can be set for executing the Store Accumulator instruction that writes to the processor I/O port.

But while in-circuit emulation would indicate whether the instruction is executed, it would not show the results of the execution, that is, it would miss the address-bus information being decoded as a specific I/O port and data-bus information toggling a flip-flop in the GPIB circuitry. This sequence can be observed, however, using a data-domain logic analyzer.

In this case, the logic analyzer works as a passive observer. As the processor executes instructions in real time under control of its own clock, the analyzer

2. To locate a memory fault, start by comparing the critical timing signals on a logic analyzer (a) with the timing diagram of a manufacturer (b). The culprit, in this case, is a precharge pulse shown on the logic analyzer's channel F. It measures .050 µs (c)—the spec states it should be at least .150 µs. The fix is made by selecting a count circuit, which will cause the precharge pulse to go high earlier, resulting in RAS precharge pulse widths of .170 µs (channel F)—well within spec (d).

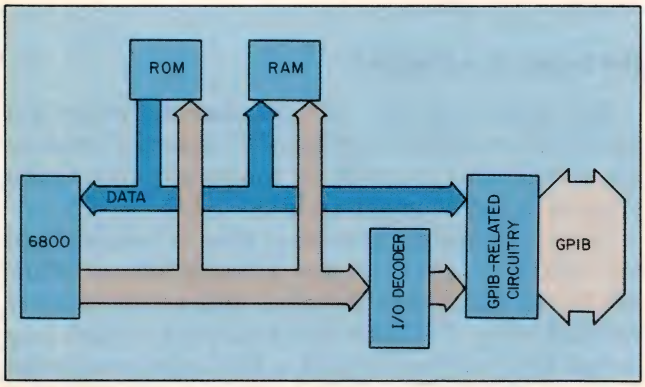
can be triggered off the address of a specific instruction, capturing the results of that instruction on ancillary circuitry.

Typically, data-domain logic analyzers can store up to 32 channels of information, with up to 512 bytes per channel. Data can be displayed in hexadecimal, binary or octal format.

To locate the source of the problem, set the logic analyzer to trigger on the address instruction (Store-Accumulator) that stores data to GPIB hardware. This turns out to be EC3E, as calculated from a program listing. The 32 channels of the logic analyzer would be connected as follows:

Channel	**Signal**
16-31	**Address bus$_{16}$**
10-15	**Unused**
9	**Flip-flop in GPIB circuitry (binary)**
8	**Read/$\overline{\text{write}}$ line (binary)**
0-7	**Data bus$_{16}$**

The display of the data and address buses indicates whether the instruction is executing properly. The read-write line shows that the data have been written to the GPIB circuitry, and the probe at the GPIB circuitry flip-flop shows if the data got that far.



3. Something is wrong here: The program of a 6800-based system is transferring one bit of status information to GPIB circuitry. However it's not reaching the GPIB circuitry. A logic analyzer helps pinpoint the source of the problem because it can take a reading not only of the μP-bus contents when a software instruction is executed, but also of the state of the I/O port or of any ancillary devices between the processor and the GPIB circuitry.

The resulting display in Fig. 4 shows the correct instruction address EC3E and later I/O address 8002$_{16}$ reached the address bus. Column 1 of the display is the analyzer's location for string information. Channel labels for channels 9 through 0 are shown at the top of the display in reverse video. While 8002$_{16}$ is on the address bus, channel 8 displays a 0, indicating a write. The data bus (channels 7 through 0) indicates an 01 is being written. However, channel 9, connected to the flip-flop, continues to read 0, indicating the data never got to the GPIB circuit.

In other words, the software is executing correctly; the error is probably a hardware glitch. It's possible to further isolate the source of the error, using the remaining channels of the logic analyzer. The probe can be moved closer to the processor to see where the signal stops.

If the logic analyzer is general-purpose (having both time domain and data domain capabilities), the analysis can be taken one step further, to the time domain. Where the signal stops, look at the timing of the incoming and outgoing signals and work backwards or forwards from there until the problem is pinpointed.

If, however, the error had been in software, it would have been easier to find the error and patch it with a development system. The logic analyzer cannot single-step through the program. What's more, patching a program with a logic analyzer involves burning a new PROM. With a development system and an in-circuit emulator, this can be done in a quick software patch.

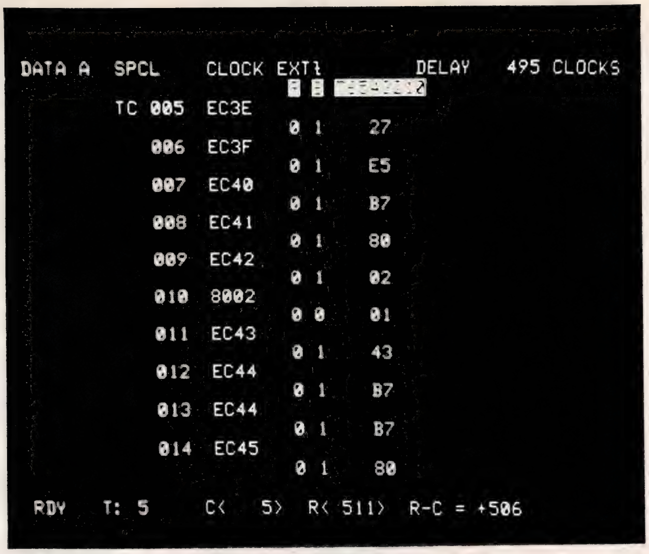
Nevertheless, without the logic analyzer, it would have been impossible to classify the problem as hardware rather than software.

Other problems, other solutions

There are plenty of other common hardware errors in μP-based systems, all of which can be pinned down with the timing-analysis capability of a logic analyzer, and not with a development system. Out-of-spec setup and hold times, for example, can bring a microprocessor right to a halt. While in-circuit emulation wouldn't be much help, an internally clocked logic analyzer would help isolate the problem.

But the analyzer has much more work cut out for it. With such ac timing specs tightening up for μPs, the analyzer must also offer greater clocking performance in the 100 to 200-MHz range. The 6800, for example, requires minimum data-in setup and hold times of 100 ns and 10 ns, respectively; the 8086, 30 ns and 10 ns.

Advanced processor designs using DMA and multiprocessing techniques also demonstrate the need for accurate multichannel timing analysis. DMA transfers, because they are transparent to the μP, are also transparent to in-circuit emulators. What's more, digging out memory and bus-contention problems that occur with multiprocessor systems requires in-depth



```
DATA A  SPCL     CLOCK EXT↿           DELAY    495 CLOCKS
                       [illegible]
        TC 005   EC3E
                       0 1      27
           006   EC3F
                       0 1      E5
           007   EC40
                       0 1      B7
           008   EC41
                       0 1      80
           009   EC42
                       0 1      02
           010   8002
                       0 0      01
           011   EC43
                       0 1      43
           012   EC44
                       0 1      B7
           013   EC44
                       0 1      B7
           014   EC45
                       0 1      80
 RDY    T: 5      C<    5>  R< 511>  R-C = +506
```

4. Catch the error on display: The correct address, 8002_{16} (column 2), is loaded onto the address bus as shown on the display of a K-100D logic analyzer. While address 8002_{16} is on the bus, channel 8 (reverse video) indicates that a write has occurred when the 0 bit appears. Yet channel 9 (reverse video) never changes state, indicating the signal never got to the GPIB circuitry.

timing analysis. This is also the case for systems interfacing with disk controllers and GPIB devices that have complex handshake-timing requirements.

In most cases, such timing errors can be found in the hardware-design stage. In other cases, however, they don't appear until the prototype or even the production stage. Take the case of the spurious error. The system runs smoothly in the lab, but fails once it's in the field. When the cover is off and the system is cool, all runs according to plan. But once the cover is on, nothing runs.

To the rescue comes a logic analyzer, with its quantitative analysis. It can indicate where timing relationships, although within spec, are marginal. Once the system heats up, these areas become the most likely sources for errors. A development system would indicate only that the system runs—not where its weak points are.

Logic analyzers are important in the data domain as well. Here, a 32-channel logic analyzer used on an 8-bit μP has at least eight probes available for monitoring control signals and tracking off-bus (address/data) faults. With available spare probes, it's possible to separate errors that occur at parallel or serial ports isolated from the processor buses using software trigger points.

The software might run glitch-free under in-circuit emulation, but not at all in the prototype. The problem is caused by the less-than-real-time execution of emulators. With a logic analyzer, the program can be observed as it executes in real time on a prototype.■■

How useful?	**Circle No.**
Immediate design application	**550**
Within the next year	**551**
Not applicable	**552**

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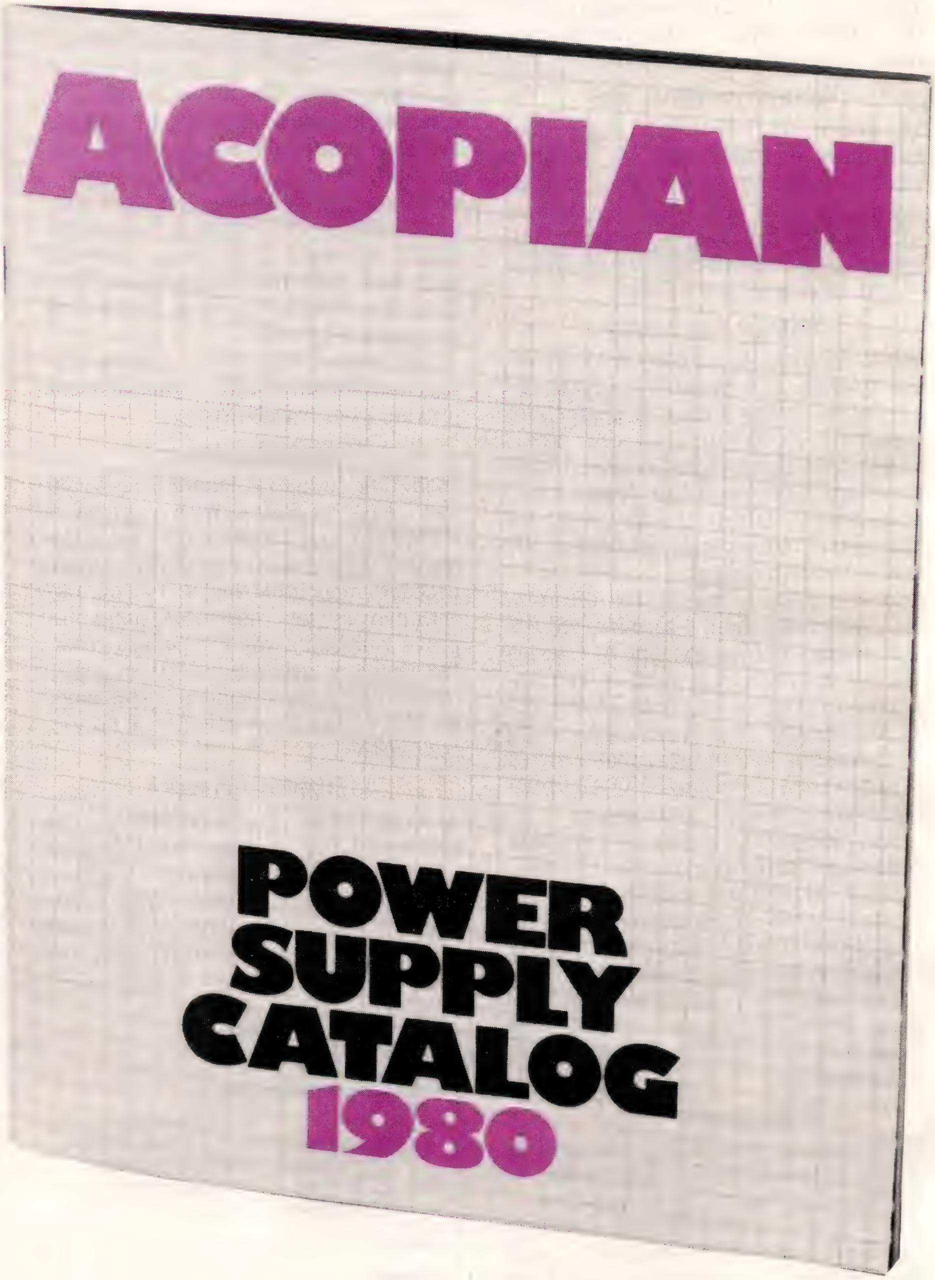

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CIRCLE NUMBER 43

Unravel multiplexed μP data with three-clock logic analyzer

The logic-state flow on multiplexed μP buses sorts out easily with the help of a logic analyzer that is geared for demultiplexing. The analyzer must have four basic capabilities:

- To trigger simultaneously on the specific address and data information
- To store that information on a qualified basis for selective editing
- To display read and write instructions and data as originally programmed; that is, on the same line as the corresponding address
- To make functional measurements, such as time-interval analyses, on the state flow.

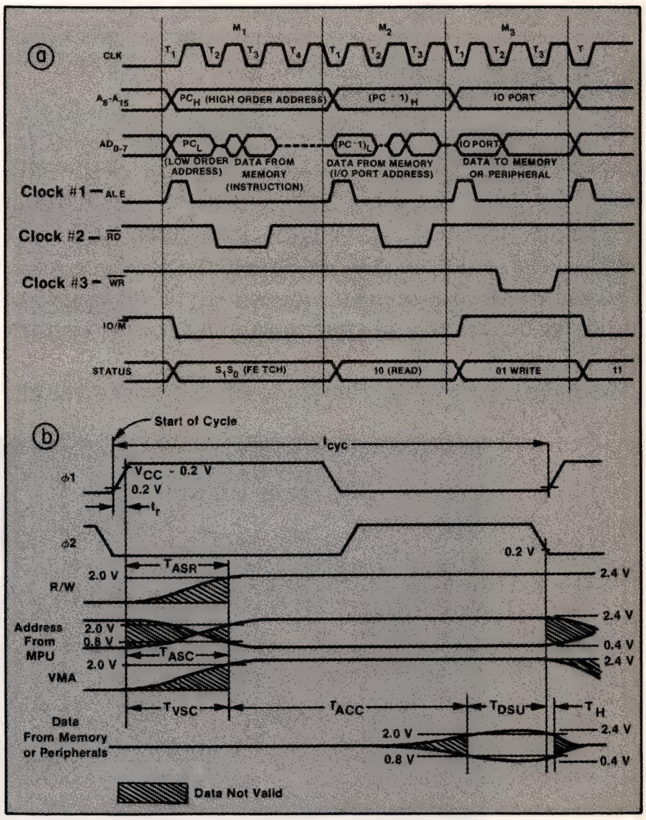
Multiplexed microprocessors like the Intel 8085 represent a technological advance aimed at retaining the 40-pin packaging configuration while freeing several pins to handle additional functions. Since 16 address lines and 8 data lines are still necessary, pins are freed by time-sharing address and data. Intel designers dedicated eight pins on the 8085 to address functions and multiplexed another eight pins to carry both address and data functions, thus using only 16 pins—rather than 24—of the available 40 for address and data.

Multiplexing in microprocessor design imposes new requirements on logic-state analyzers, but two requirements do not change. For information to be read and captured, address and data lines must be stable, and a clock line must indicate when they are. However, because eight of the 16 address lines carry both read and write data, as well as address information, additional status and control lines are necessary with multiplexing, to govern and coordinate the overall procedure (see Fig. 1a).

Status lines on the microprocessor identify the nature of the transaction being performed at a given time. But since several types of transactions can occur at different times on the same lines, address and data are no longer stable simultaneously. These transactions require separate timing strobes, and so three lines—instead of the earlier single clock line—must be dedicated to the timing of data examination and capture. The first strobe corresponds to the $\phi 2$ clock (Fig. 1b) of the Motorola 6800 and Intel 8080 designs. Known as the Address Latch Enable (ALE) line, it indicates to the microprocessor when stable conditions exist across the address lines.

The generation before multiplexing

Before multiplexing, the 8-bit, 40-pin, dual-in-line package (DIP) microprocessor configurations (8080, 6800) allocated 16 pins to address functions and eight pins to data transfer, with enough pins left over to handle all the other required operations. Data being processed by systems using these microprocessors are easily analyzed by single-clock, first-generation logic-state analyzers. As shown by the timing diagram (Fig.



1. **Today's logic analyzers require a minimum of three clocks to acquire both read and write transactions on multiplexed systems, like the 8085A (a). Most early μPs, like the 6800, did not use multiplexing for data and address (b). Consequently, first-generation logic analyzers required only a single clock input ($\phi 2$) to capture both address and data.**

Dan Kolody, Product Manager, Hewlett-Packard, 1900 Garden of the Gods Rd., Colorado Springs, CO 80901.

1b), the data capture procedure for the 6800 establishes simultaneous stability across all 16 address and eight data lines and employs the required timing signal.

In Fig. 1, stability is indicated on the address and data lines by $T_{ACC} + T_{DSU}$. The cross-hatched areas show changing states on the lines, and thus unstable conditions. Within a particular cycle, stable conditions always exist at one point across both sets of lines—at the falling edge of the phase-two ($\phi 2$) clock. That event is, therefore, ideal for the timing signal in the data-capture process. The analyzer is instructed to read the address and data information on the lines at that precise point in each cycle, and to compare it with the trigger and storage conditions. When the trigger or storage conditions or both correspond exactly with the information on the address lines and/or the data and control lines, the analyzer captures the data for display.

In some analyzers, a general-purpose module solves the problem of demultiplexing. In the HP 1611A, for one, the module incorporates a multiple-clock system to allow multiplexed information on a common bus structure to be latched into the unit's inputs at the appropriate time for display. Another unit, the HP 1610B (See ELECTRONIC DESIGN, June 21, 1979, p. 133) employs three clocks integrally. Designated J, K and L, the clocks operate along with a buffer memory and share a master-slave relationship (Fig. 2).

Three clocks set the pace

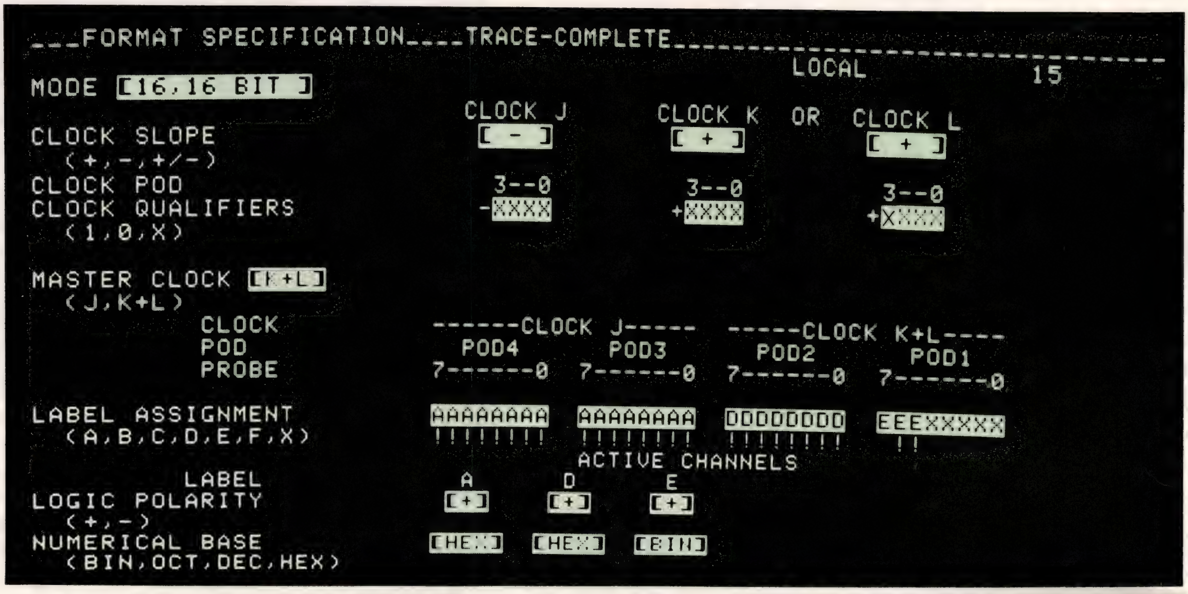
In the case of the multiplexed 8085's timing cycle, address stability occurs at the falling edge of the ALE. The rising edge of the read ($\overline{RD}$) line signals that stable conditions exist on the eight data lines and that information summoned from the memory can be read. The write ($\overline{WR}$) line operates identically. Its rising edge indicates stability and that data can be written into the memory.

In operation, the ALE line is monitored by the J clock, (Fig. 3), which is the slave. On the falling edge of the ALE, the J clock tells the analyzer to read the address information across all 16 address and address/data lines. This information is then stored in a buffer memory. At the same time, the K and L clocks keep a constant watch on the $\overline{RD}$ and $\overline{WR}$ lines. These clocks can be ORed in the analyzer and designated as master clocks: the last to occur in the time sequence. When trigger conditions are matched by information on the bus, read or write data are captured and transmitted to the buffer, to be attached to the waiting address information. The buffer content is then displayed on the screen as a single, useful line of information containing both address and relevant data (Fig. 4).

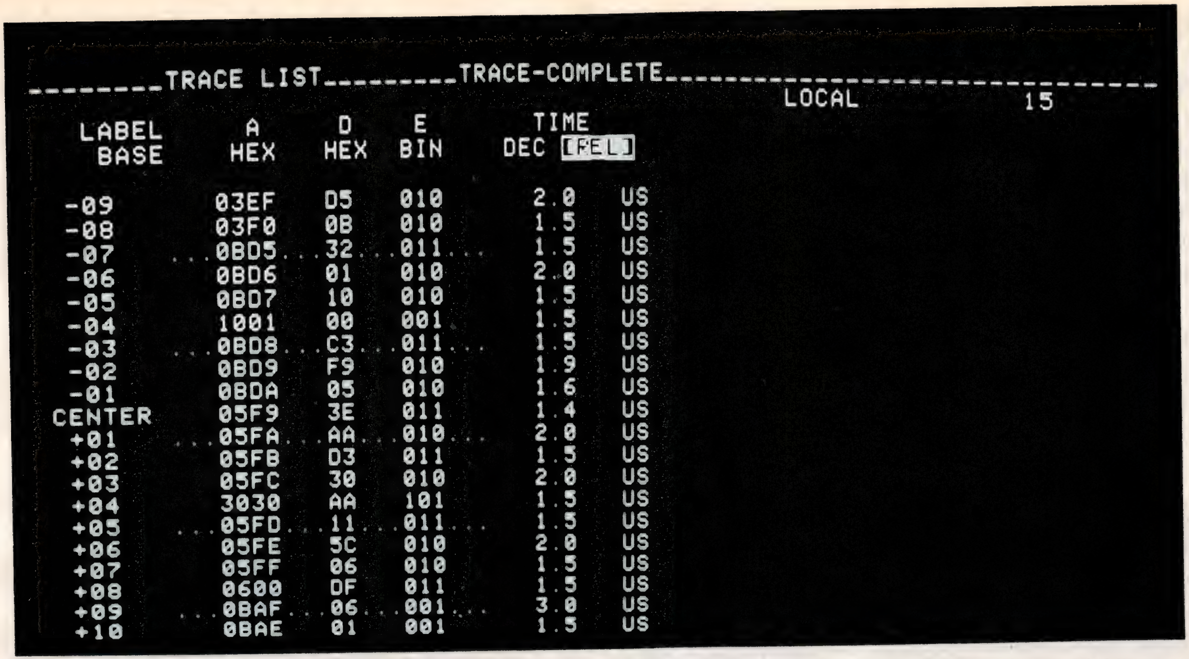
Although the three-clock approach is designed to accommodate μPs with eight-address-line, eight-address/data-line multiplexing—the format found in the 8085—it works equally well with Intel's newer μP, the 16-bit 8086.

The 8086 goes one step further in that all the address

2. Three clocks in a single analyzer (see display) ease design and troubleshooting in digital systems with multiplexing (above). With the 8-bit 8085, the ORed combination of the last two clocks, K and L, produces the master clock, which strobes all acquired information into the logic analyzer (below).

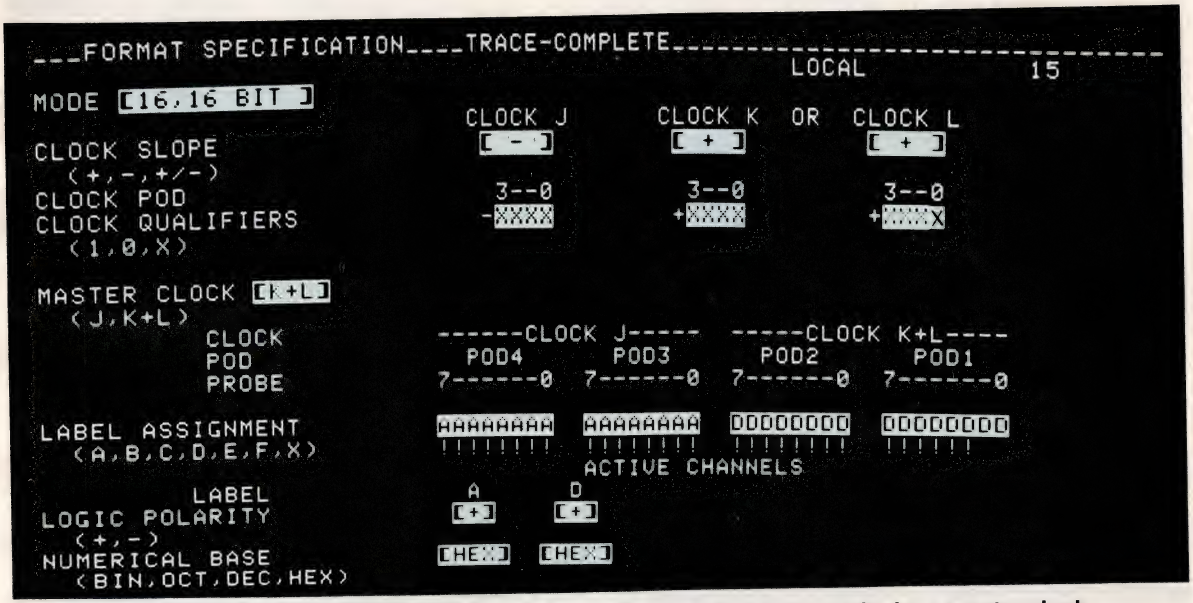


```
___FORMAT SPECIFICATION____TRACE-COMPLETE______________________
                                              LOCAL            15
MODE [16,16 BIT ]
                          CLOCK J      CLOCK K  OR  CLOCK L
CLOCK SLOPE               [ - ]        [ + ]        [ + ]
  (+,-,+/-)
CLOCK POD                  3--0         3--0         3--0
CLOCK QUALIFIERS          -XXXX        +XXXX        +XXXX
  (1,0,X)

MASTER CLOCK [K+L]
  (J,K+L)
               CLOCK      ------CLOCK J-----  -----CLOCK K+L----
               POD          POD4      POD3      POD2      POD1
               PROBE      7------0  7------0  7------0  7------0

LABEL ASSIGNMENT          AAAAAAAA  AAAAAAAA  DDDDDDDD  EEEXXXXX
  (A,B,C,D,E,F,X)         !!!!!!!!  !!!!!!!!  !!!!!!!!  !!
                               ACTIVE CHANNELS
             LABEL          A         D         E
LOGIC POLARITY            [+]       [+]       [+]
  (+,-)
NUMERICAL BASE            [HEX]     [HEX]     [BIN]
  (BIN,OCT,DEC,HEX)
```



```
--------TRACE LIST---------TRACE-COMPLETE------------------------------
                                                  LOCAL             15
  LABEL       A      D     E       TIME
   BASE      HEX    HEX   BIN     DEC [REL]

  -09       03EF    D5    010      2.0    US
  -08       03F0    0B    010      1.5    US
  -07    ...0BD5...32...011...     1.5    US
  -06       0BD6    01    010      2.0    US
  -05       0BD7    10    010      1.5    US
  -04       1001    00    001      1.5    US
  -03    ...0BD8...C3...011...     1.5    US
  -02       0BD9    F9    010      1.9    US
  -01       0BDA    05    010      1.6    US
 CENTER     05F9    3E    011      1.4    US
  +01    ...05FA...AA...010...     2.0    US
  +02       05FB    D3    011      1.5    US
  +03       05FC    30    010      2.0    US
  +04       3030    AA    101      1.5    US
  +05    ...05FD...11...011...     1.5    US
  +06       05FE    5C    010      2.0    US
  +07       05FF    06    010      1.5    US
  +08       0600    DF    011      1.5    US
  +09    ...0BAF...06...001...     3.0    US
  +10       0BAE    01    001      1.5    US
```

3. A trace list of data acquired from a multiplexed system displays each address and the associated data and control-line information on a single line, even though the data are not carried concurrently.



```
---FORMAT SPECIFICATION----TRACE-COMPLETE------------------------------
                                                LOCAL             15
MODE [16,16 BIT ]
                             CLOCK J        CLOCK K   OR   CLOCK L
CLOCK SLOPE                   [ - ]          [ + ]          [ + ]
  (+,-,+/-)
CLOCK POD                      3--0           3--0           3--0
CLOCK QUALIFIERS              -XXXX          +XXXX          +XXXX
  (1,0,X)

MASTER CLOCK [K+L]
  (J,K+L)
             CLOCK          ------CLOCK J-----   -----CLOCK K+L----
             POD              POD4      POD3       POD2      POD1
             PROBE          7------0  7------0   7------0  7------0

LABEL ASSIGNMENT            AAAAAAAA  AAAAAAAA   DDDDDDDD  DDDDDDDD
  (A,B,C,D,E,F,X)           !!!!!!!!  !!!!!!!!   !!!!!!!!  !!!!!!
                                    ACTIVE CHANNELS
            LABEL              A         D
LOGIC POLARITY               [+]       [+]
  (+,-)
NUMERICAL BASE              [HEX]     [HEX]
  (BIN,OCT,DEC,HEX)
```

4. The format-specification menu allows the user to define one, two or three clocks; a master clock; clock edges; and clock qualifiers. The format shown is for the 8086 μP; 16 bits of address are multiplexed with 16 bits of data.

lines are multiplexed to double as data lines. The added data lines vastly increase the microprocessor's instruction capacity. However, switching from the 8085 to the 8086 requires a different analyzer hook-up technique.

The 1610B, a 32-bit analyzer, accepts 8 bits of information through each of four pods, designated 4, 3, 2 and 1. With the 8085, the 1610B is instructed to monitor pods 4 and 3 according to the J-clock timing sequence. The 16 inputs of pods 4 and 3 are hooked up to the 16 address lines, the eight inputs of pod 2 are hooked up to the data lines, and the information coming over those lines is read using the K clock for read data and the L clock for write data. Since the data lines are multiplexed with eight of the address lines, each line actually has two probes—one from pod 3, reading addresses and governed by the J clock; and one from pod 2, reading data and controlled by both the K and L clocks (Fig. 3). Because the 8086 multiplexes all 16 address and data lines, all 16 are now double-probed; master clock J controls the reading of address information through pods 4 and 3, and clocks K and L strobe read and write data, through pods 2 and 1 (Fig. 5).

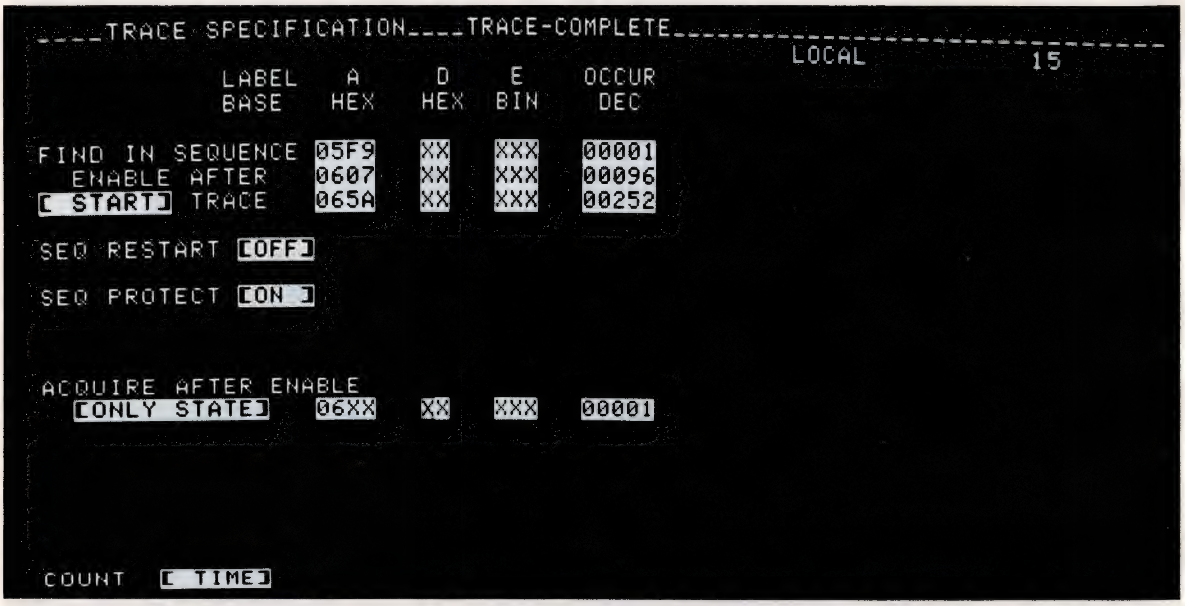
But what of other μPs, with other timing cycles? A logic analyzer must be flexible enough to handle various designs. One accommodation is to offer the user a menu.

With a menu program format, a user can define not just the necessary clock options but selective triggering conditions and data display as well. From the keyboard, the user can select format specification, trace specification, trace list, trace compare or trace graph menus. The two specification menus provide parameter selection in setting up a measurement. On the format specification menu, for example (Figs. 3 and 5), parameter selection involves one or more of the three clocks: defining the master clock, selecting the rising or falling edges of each or both, and setting qualifiers for each clock. It is also possible to switch the clocks off.

Data can be captured under three different modes, 32-bit, 16-16-bit or 16-8-8-bit. In the 32-bit mode, all data present on the four data pods clock into the logic analyzer on the selected active edges of the ORed combination of clocks J, K and L. This mode goes hand-in-hand with the 8080 or 6800. In the 16-16-bit mode (for 8085 and 8086-type processors), data from pods 4 and 3 strobe into the logic analyzer on the active edge of clock J, while data from pods 2 and 1 enter on the ORed combination of K and L. Selection of the 16-8-8-bit mode calls for data from pods 4 and 3 to enter with clock J, data from pod 2 to enter with clock K, and data from pod 1 to strobe-in with clock L.

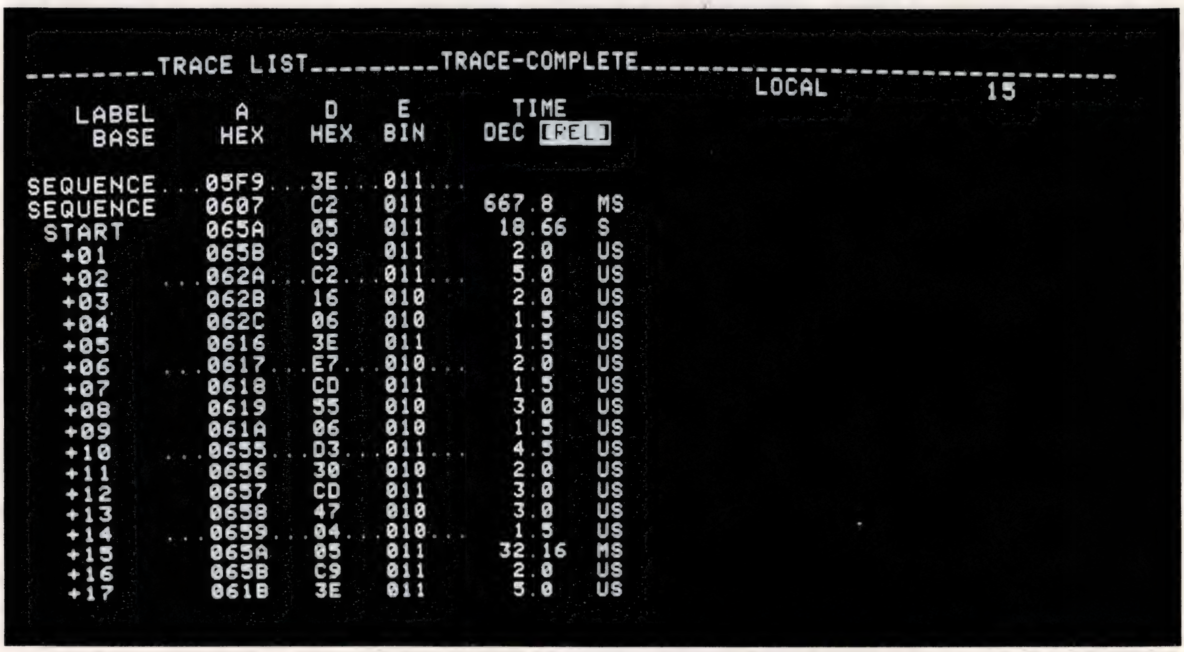
Clock qualifiers provide a flexible window

Associated with each clock are up to four qualifier minterm bits, each of which can be set to ONE, ZERO or X (don't care) with entry keys. The qualifier



```
____TRACE SPECIFICATION____TRACE-COMPLETE_________________________________
                                                        LOCAL            15
                 LABEL    A      D     E      OCCUR
                 BASE    HEX    HEX   BIN     DEC

FIND IN SEQUENCE  05F9   XX     XXX   00001
   ENABLE AFTER   0607   XX     XXX   00096
[ START] TRACE    065A   XX     XXX   00252

SEQ RESTART [OFF]

SEQ PROTECT [ON ]


ACQUIRE AFTER ENABLE
  [ONLY STATE]    06XX   XX     XXX   00001




COUNT  [ TIME]
```

5. The trace-specification menu allows the user to define the initial state or state sequences at which to begin data acquisition, and what kinds of information will be collected.



```
________TRACE LIST__________TRACE-COMPLETE_______________________________
                                                      LOCAL           15
   LABEL       A       D    E        TIME
    BASE      HEX     HEX  BIN     DEC [REL]

SEQUENCE...05F9...3E...011...
SEQUENCE   0607    C2   011    667.8   MS
 START     065A    05   011     18.66  S
   +01     065B    C9   011      2.0   US
   +02  ...062A...C2...011...    5.0   US
   +03     062B    16   010      2.0   US
   +04     062C    06   010      1.5   US
   +05     0616    3E   011      1.5   US
   +06  ...0617...E7...010...    2.0   US
   +07     0618    CD   011      1.5   US
   +08     0619    55   010      3.0   US
   +09     061A    06   010      1.5   US
   +10  ...0655...D3...011...    4.5   US
   +11     0656    30   010      2.0   US
   +12     0657    CD   011      3.0   US
   +13     0658    47   010      3.0   US
   +14  ...0659...04...010...    1.5   US
   +15     065A    05   011     32.16  MS
   +16     065B    C9   011      2.0   US
   +17     061B    3E   011      5.0   US
```

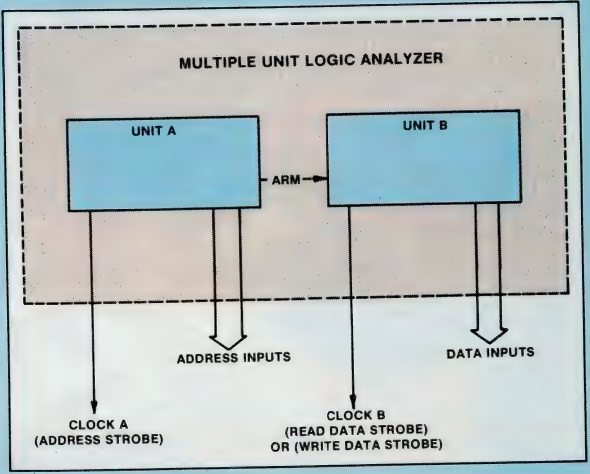
6. Functional measurements can quickly isolate atypical data flow. In this trace list, which consists only of states from address $06XX_{16}$, a quick examination of the elapsed time (right-hand column) uncovers an anomaly at state +15. The time interval of 32.16 ms may indicate a problem.

All demultiplexers are not alike

One of the early approaches to demultiplexing put a sequential acquisition system into a single package (see fig.). Unit A reacts to the ALE, and unit B to either the $\overline{\text{RD}}$ or the $\overline{\text{WR}}$. Although this approach does separate out the address and one read or write function, it cannot be viewed as true demultiplexing since it does not correct for the real-time differential between the capture of address information and the capture of read/write information.

The system has several disadvantages. For example, if all transactions are to be analyzed, the hardware requires additional external circuitry to OR the read and write signals. Because of the time difference, the dual-clock design often is unable to display address and data on the same line—it skews the address and data by one line or it stacks the information together in the same columns, making it difficult to compare the information with the original program and to take functional measurements.

Of greater significance is the possibility of errors in analysis. If the analyzer is instructed to capture a specific address and data combination, unit A will trigger on the address and arm unit B. However, the data at that specific address may be a variable, and unit B will not trigger until it reads the specific data required. That data may appear later in the program and will be captured, since unit B is armed—even though the data are not associated with the specified address at the moment of capture. To be effective, therefore, unit A must reset if the data trigger word does not appear in conjunction with the address trigger word.



monitors status lines and allows data to be stored only when certain conditions are met—when an I/O write operation occurs, for example. Since each clock input accepts up to four qualifiers, the user can choose which address and data-line information to display.

For even easier analysis and interpretation of captured data, the 32 input channels can be grouped under one or more of six labels: 16 bits from an address bus could be labelled "A"; 8 bits from a data bus, "D", 3 bits from control lines, "E"; and two other control lines, "F". Any further specifications on these inputs apply to the whole group rather than to individual lines. Each group can then be defined independently in positive or negative logic, and assigned a binary, decimal, octal or hexadecimal numerical base. For a quick overview of system activity, all channels with activity are noted with exclamation marks.

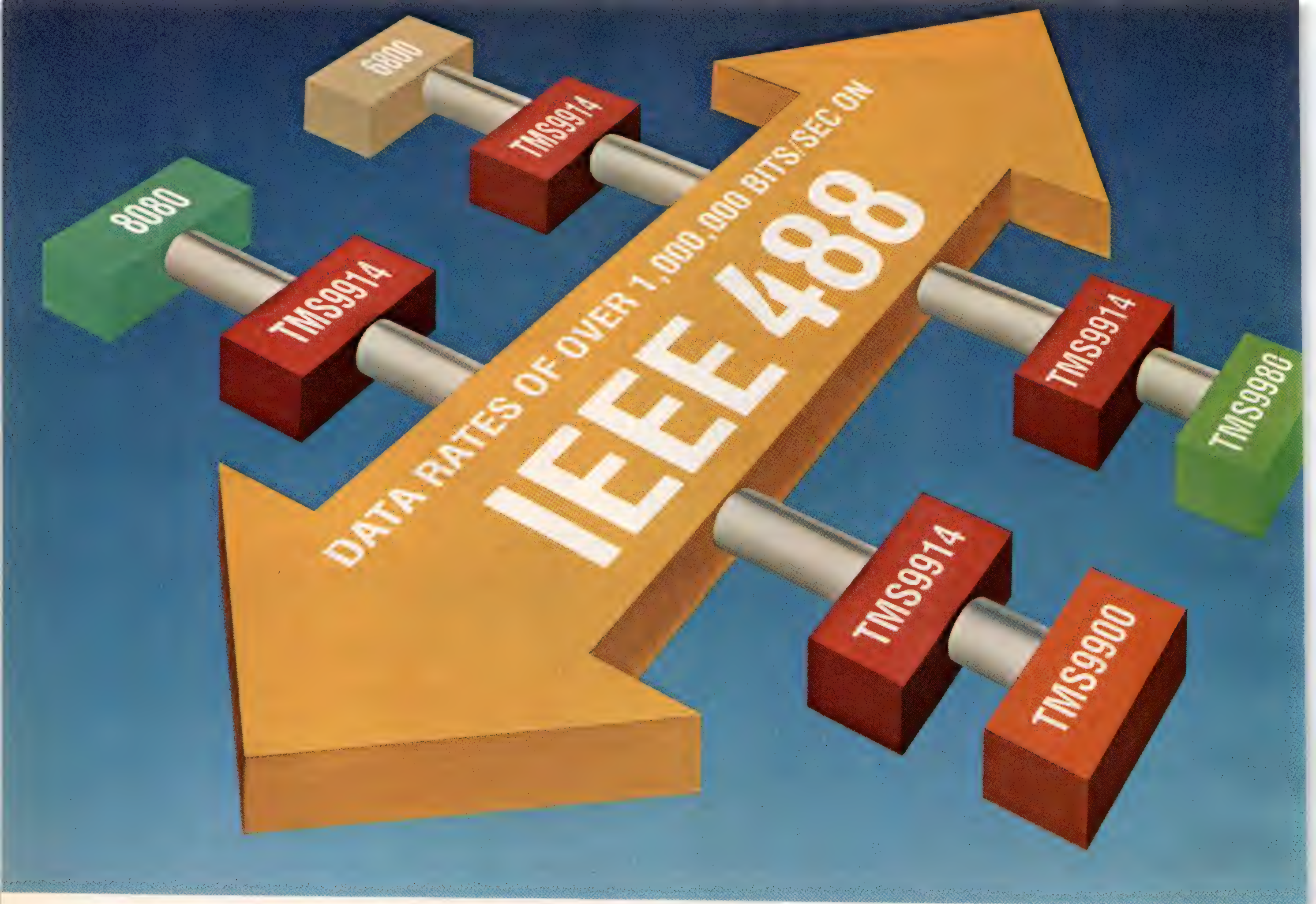
Whereas clock qualifiers select which data will be strobed into holding registers or the current line, the trace specification menu (Fig. 5) gives the user flexibility in selecting the exact trigger point desired in a program and in establishing which data will be displayed. For example, in Fig. 6, trace-specification parameters have been set to find in sequence the first occurrence of $05F9_{16}$, the 96th occurrence of 0607_{16} and 252nd occurrence of $065A_{16}$. Thus, users can easily locate specific portions of nested loops—as in a program that samples many peripherals (a major loop), receives data from each peripheral (a minor loop) and then formats the data from each data transmission (a subminor loop).

Further storage qualification allows the user to edit program flow selectively and display only the information of interest. In Fig. 5, the trace resulting from this menu will consist of states in which label A values fall between 0600_{16} and $06FF_{16}$. Selective editing considerably reduces the need for larger memory while simplifying analysis by deleting extraneous data from the display.

Whatever other qualities a demultiplexing analyzer has, it should not sacrifice its ability to make elapsed time-interval measurements. With this capability, users can determine both the total program execution time and the time required for a specific task, like a multiplication subroutine.

Time-interval measurements can also prove valuable in detecting program errors. In Fig. 6, examination of elapsed time between state +15 ($065A_{16}$) and the previous state +14 (0659_{16}) shows a result of 32.16 ms. The question that arises is: Why the large time differential between 0659 and 065A compared with other adjacent states? Only a detailed examination of microcode will answer the question. But it takes just a brief look at relative elapsed time to locate this apparent anomaly. ■■

How useful?	**Circle No.**
Immediate design application	**553**
Within the next year	**554**
Not applicable	**555**



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Under designer's guidance, logic analyzer deploys its full strength against crashes

When the full capabilities of a logic analyzer are exploited, even elusive design problems may be tracked down and disclosed. But the designer's analysis of the situation must back up the instrument; he must know all the abilities of the logic analyzer and call upon them systematically (see "Adding another dimension to logic analysis"). An ideal analyzer should be able to:

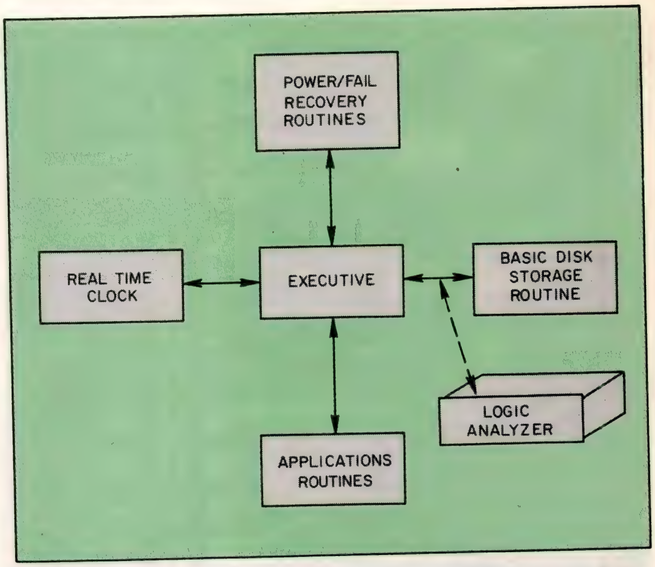
- Compare known good data in its reference memory with data in its source memory
- Trigger on and collect events in the state domain and simultaneously collect events in the time domain
- Pretrigger so that data can be collected both before and after the trigger
- Trigger off a time-domain event and simultaneously collect events through a waveform analysis channel.

Suppose that a small, prototype, computer system (Fig. 1) with disk drive, printer and CRT peripherals is installed at a data site; for no apparent reason, the disk writes bad data at random intervals, sometimes two or three days apart, bringing the entire system to an error halt. The randomness and lack of distinct symptoms suggest the need for long-term monitoring by a logic analyzer, which will trigger at any abnormal occurrence. (For brevity, the following analysis skips the "dead ends" that normally occur in this kind of debugging.)

The logic analyzer joins the pursuit

After a system failure, one initial response may be to replace the disk and controller to ensure that the hardware, which appears to be operating normally, is not actually at fault. With the 540 logic analyzer, the performance of the firmware controlling the disk can be verified against specifications. If the system fails again, the designer logically can assume the malfunction is in the software or is a combined software-hardware failure. The next step, therefore, is to analyze those functional software modules that appear to be related to the specific problem. The software is organized as four functional modules under the control of an executive module (Fig. 2). The

1. An unknown culprit is causing a disk-based computer system to fail. The problem appears to be that erroneous data are being written into the disk status, resulting in a complete system failure. The elusive nature of the problem makes it an ideal candidate for a logic analyzer.



2. Five modules constitute the software of the computer system. A process of elimination isolates the problem to either the power/fail recovery or basic disk-storage routine software.

Ira H. Spector, President, **Rick Muething,** Vice President, Paratronics, Inc., 800 Charcot Ave., San Jose, CA 95131.

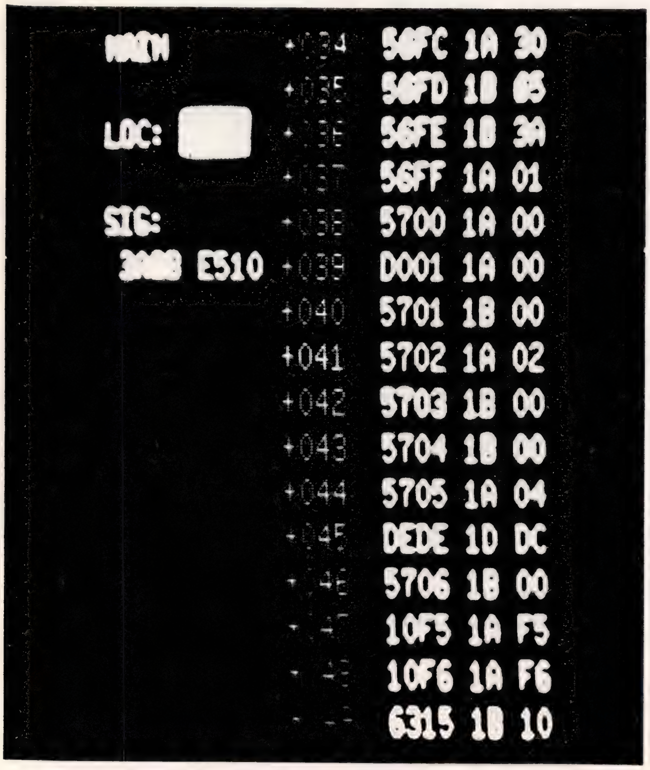
application and real-time clock modules along with the executive are unlikely candidates because they have been verified and do not interface directly to the disk.

The two remaining modules are equally likely culprits. The power-fail-recovery software ensures that the system shuts down in an orderly fashion whenever ac power is lost, and that the system comes back on line in an orderly sequence when power is restored. The basic disk storage routines are used by all the other software to access data within the various tracks and sectors on the rotating disk. Problems seem to be indicated in either or both of these routines.

The software is the easiest part of the system to monitor with the analyzer. The system comes equipped with a maintenance port that taps into all lines of the system bus. When the logic-analyzer's state-domain channels are connected to the port, the designer can monitor every instruction executed by the system. However, not every instruction needs to be collected, since some are very unlikely sources of the problem. Properly set up, the analyzer can detect and capture a malfunction as it occurs without operator involvement.

The clearest symptom of the problem in the sample system is data corruption on the disk. Thus, the logic analyzer is configured to capture an execution of the basic disk routines. This sample execution of the routines is then stored in the reference memory of the analyzer. The analyzer is configured for hold operation, making repetitive collections, stopping only when the collected data differs from a previously stored reference (Halt on difference). The real-time memory then contains all the program executions at the time of the fault.

As shown in Fig. 3, the analyzer stops recording —because the error (a difference) has occurred— immediately after the execution of the instruction in address 5706. Data collection stops because the next instruction in the sequence deviates from the normal flow of the reference disk routines. The address 10F7 is that of the power-fail interrupt program. The analyzer has caught the system experiencing power failure and attempting to execute the appropriate routine.



```
[illegible]        +034  56FC 1A 30
                   +035  56FD 1B 05
LOC:               +036  56FE 1B 3A
                   +037  56FF 1A 01
SIG:               +038  5700 1A 00
 [illegible] E510  +039  D001 1A 00
                   +040  5701 1B 00
                   +041  5702 1A 02
                   +042  5703 1B 00
                   +043  5704 1B 00
                   +044  5705 1A 04
                   +045  DEDE 1D DC
                   +046  5706 1B 00
                   +047  10F5 1A F5
                   +048  10F6 1A F6
                   +049  6315 1B 10
```

3. **Shown above is the display after the analyzer has detected a difference between the program stored in its reference memory and the actual program execution it monitored.**

Adding another dimension to logic analysis

To state and time-domain capability, the Paratronics PI 540 logic analyzer adds a waveform-recording channel. All three features can be linked together in operation, so that events occurring in one section trigger recording in another. A trigger can occur on any ANDed combination of state, timing, waveform or external events.

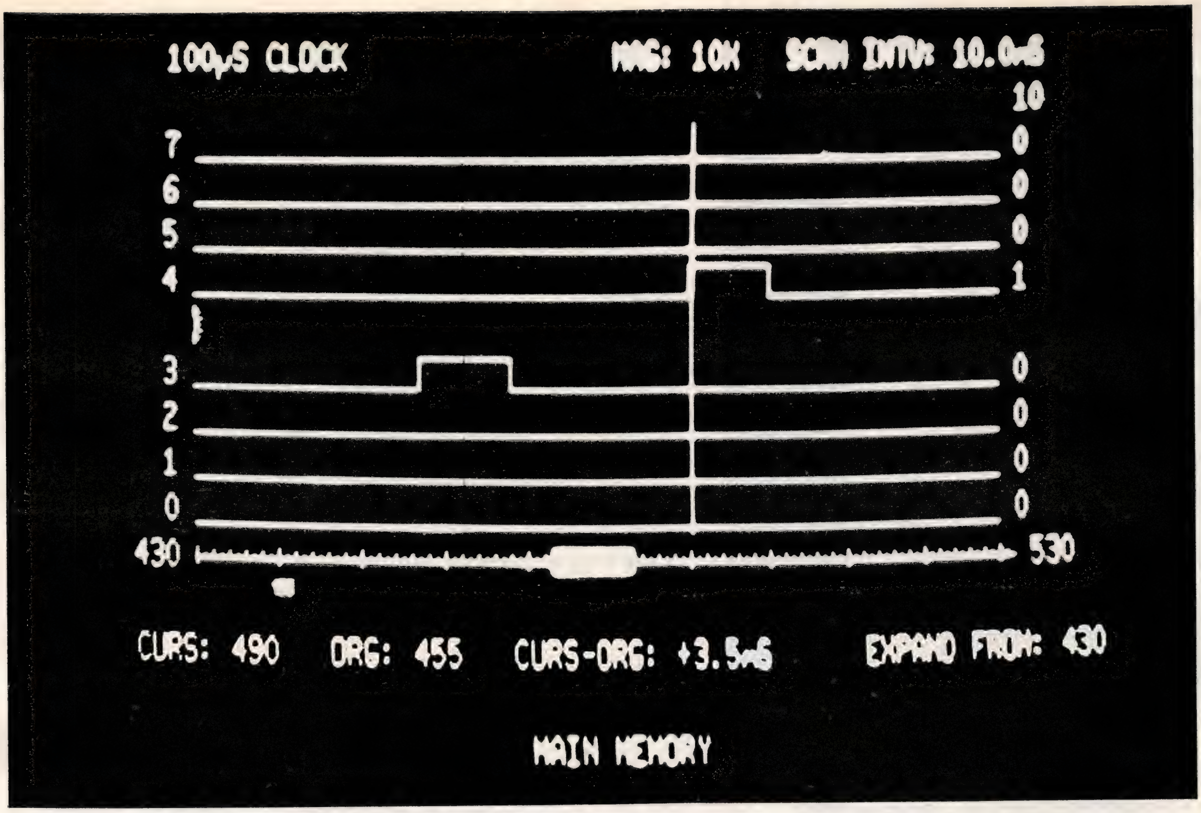
In the 40-channel analyzer, 32 synchronous state-domain channels (each 250 bits deep) run at a 15-MHz sample rate, and eight timing channels (1000 bits deep) run at a 50-MHz synchronous or asynchronous rate. Each timing channel is able to capture a glitch down to 5 ns. The analog channel (1000 samples deep) boasts a 50-MHz sample rate, 15-MHz effective bandwith and 6-bit resolution.

Other hardware and software features of the unit —16 levels of sequential triggering, signature analysis capability and five state displays (including decimal and ASCII)—assist the operator in using the instrument more effectively.

The culprit leaves clues

While an abnormal condition is therefore indicated, it does not in itself explain the problem. The system has power-fail and restart programs designed in to handle just such exigencies. All that has been observed is the system performing normally in the face of a power loss. The storage unit also has an error recovery routine which should have prevented the system from destroying data as a result of the power failure.

To learn more about the causes of the problem, the designer establishes new monitoring points and a new trigger point, on the basis of the information acquired from the analyzer thus far and of the system's behavior at the time of the failure. Because the error appears to occur about the time of the power-fail interrupt, the eight time-domain channels of the analyzer are used to monitor power fail and restart and the six other interrupts that are subject to timing errors. Since the analyzer's 32 state-domain channels are still connected to the system bus, the instrument will trigger on and collect events occurring in the state domain as it simultaneously collects events in the time domain.



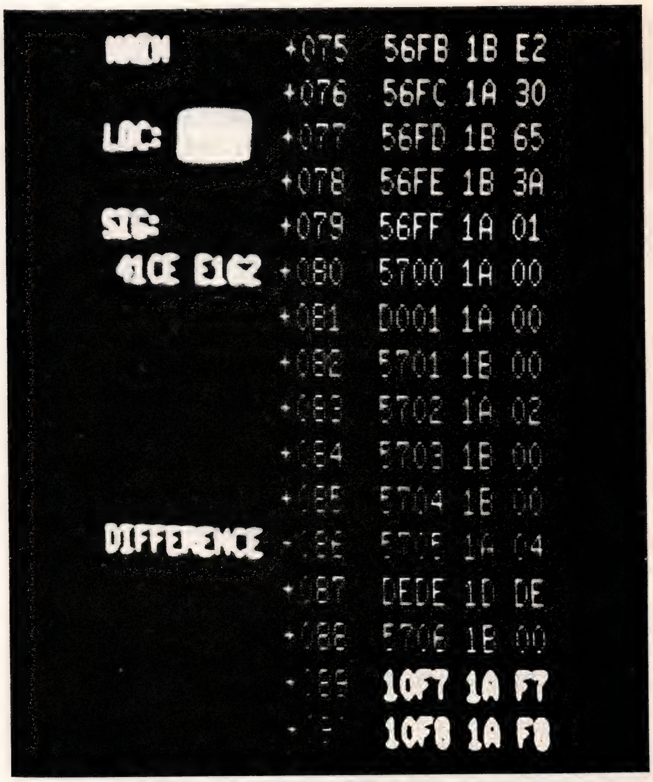
4. On the eight channels of the analyzer's display, several events occurring asynchronously within the computer system were monitored during troubleshooting, in an attempt to learn more about the cause of the problem. When the system failed the second time, the instrument recorded the power-down and power-restart interrupts shown.

The analyzer is set to pretrigger; that is, to collect a certain number of words before and after the trigger event. Since the system fails after entering the power-failure routine, the trigger condition is set for this routine and in such a way that 50% of the analyzer's timing memory fills after the trigger. This memory can store 1000 words; thus, 500 words are recorded prior to the trigger and 500 afterwards. In this configuration, the analyzer catches the time-domain information in Fig. 4, which displays power-fail and power-restart interrupts. It also records 32 channels of state (Fig. 5) after the power-fail routine starts.

An analysis of the program flow reveals that the power-fail routine was disrupted part way through by another interrupt. This prevented the completion of the disk routines and the system crashed.

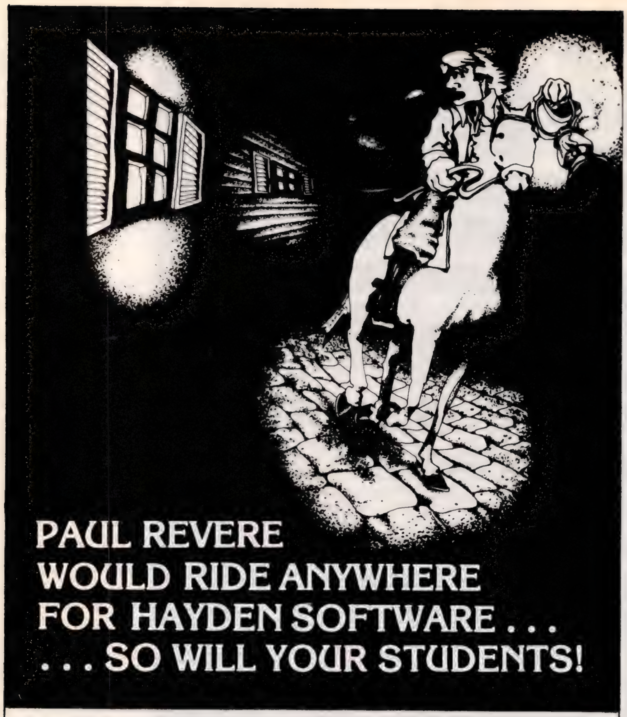
In the analyzer's time-domain display of the eight interrupt conditions monitored, only the power-fail and power-recovery interrupt show activity. When the timing display of the two interrupts is enlarged (the analyzer can magnify up to 20 times), the time difference between the power fail and restart interrupts is shown as taking 3.5 ms. However, the system requires 10 ms to execute the power-fail routine—6.5 ms longer.

Thus, the duration of the line-voltage failure was shorter than the time required to execute the system's power-down routine. Before the routine could be completed, power was restored and the system attempted to restart; the disk routine attempted to restore incomplete status and the crash followed. This



```
MAIN        +075  56FB 1B E2
            +076  56FC 1A 30
LOC:        +077  56FD 1B 65
            +078  56FE 1B 3A
SIG:        +079  56FF 1A 01
 41CE E1C2  +080  5700 1A 00
            +081  D001 1A 00
            +082  5701 1B 00
            +083  5702 1A 02
            +084  5703 1B 00
            +085  5704 1B 00
DIFFERENCE  +086  5705 1A 04
            +087  DEDE 1D DE
            +088  5706 1B 00
            +089  10F7 1A F7
            +090  10F8 1A F8
```

5. Also captured during the second system failure is the state information shown above. It reveals the orderly execution of a routine, disrupted by an interrupt which triggered the logic-analyzer recording.



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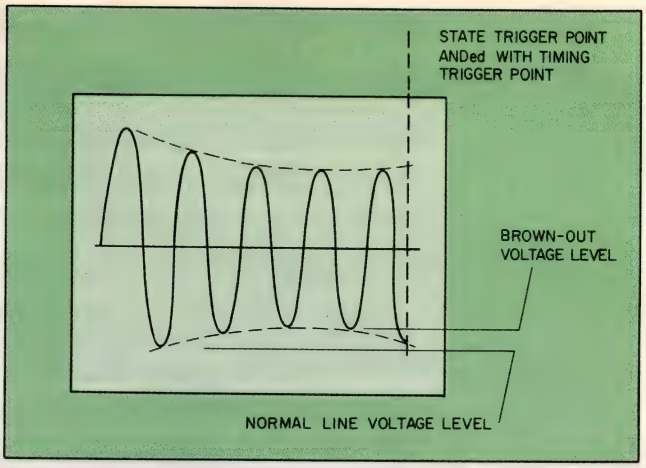

6. A momentary dip-in-line current caused the system failure. The power fell below the system's failure threshold for less than one 60-Hz ac alternation—just long enough to trigger the fault, but short enough to prevent a complete and orderly shut-down before power returned to its normal level.

planation is plausable but does not explain the short duration of the power outage.

Suspecting a brown out condition, the designer attempts to capture the reduced value of line voltage that produced the problem. This analysis makes use of a feature that is relatively new to logic analyzers, a waveform-analysis channel. The channel contains an analog-to-digital converter front-end and 1000 bits of high-speed memory to collect the digitized analog signal at a fast 50 MHz sample rate—more than adequate to capture the possible elusive fluctuations in ac line voltage. The instrument can simultaneously trigger off a time-domain event and collect events through the waveform channel.

For safety, the waveform channel connects to the ac line via an isolation transformer. The two time-domain channels are left tied to the power-fail and power-restart interrupts. The instrument is then set to trigger if the restart interrupt occurs less than 10 ms after the power-fail interrupt.

For this triggering condition, the timing section of the analyzer is configured to run with a 100-μs sample period and a trigger window of 100 clock periods (10ms), the nominal time delay required by the system between the two interrupts. With this trigger condition only an erroneous power-fail-restart sequence will be recorded.

On the next system failure, the waveform in Fig. 6 is observed in the analyzer display. It clearly shows the short-duration dip-in-line voltage.

Thus, the analyzer locates, not a component failure or software bug, but a conceptual design flaw: It has diagnosed a misassumption by the designer—that the system would always have at least the 10 ms needed to execute its power-down routine to completion. ■■

How useful?	**Circle No.**
Immediate design application	**556**
Within the next year	**557**
Not applicable	**558**

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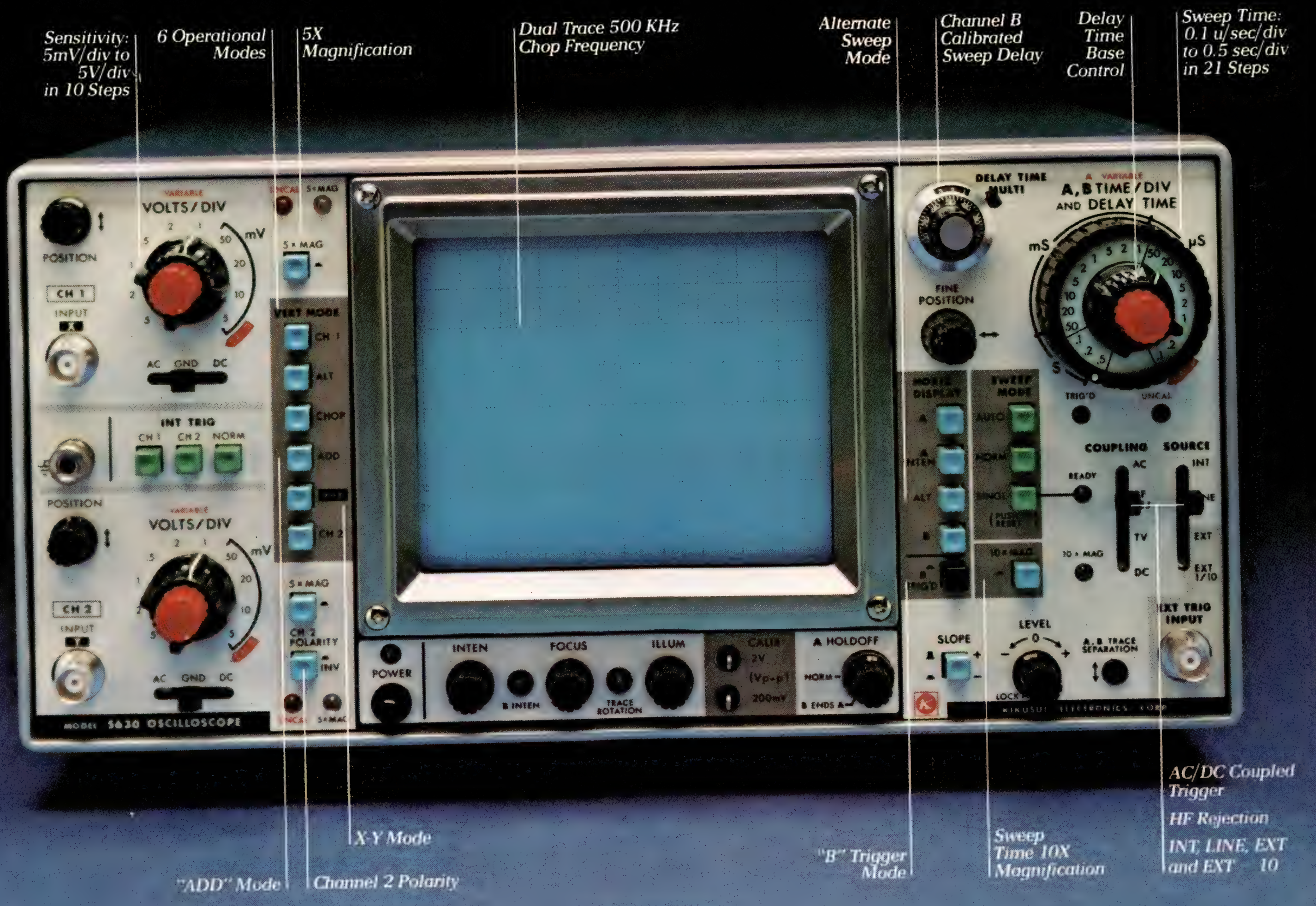

CIRCLE NUMBER 45

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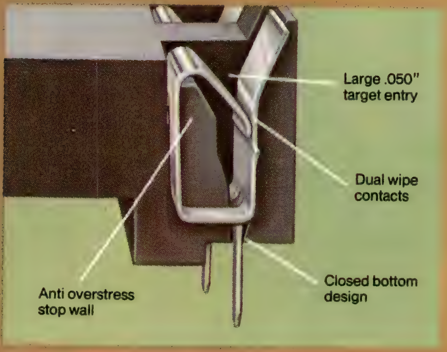

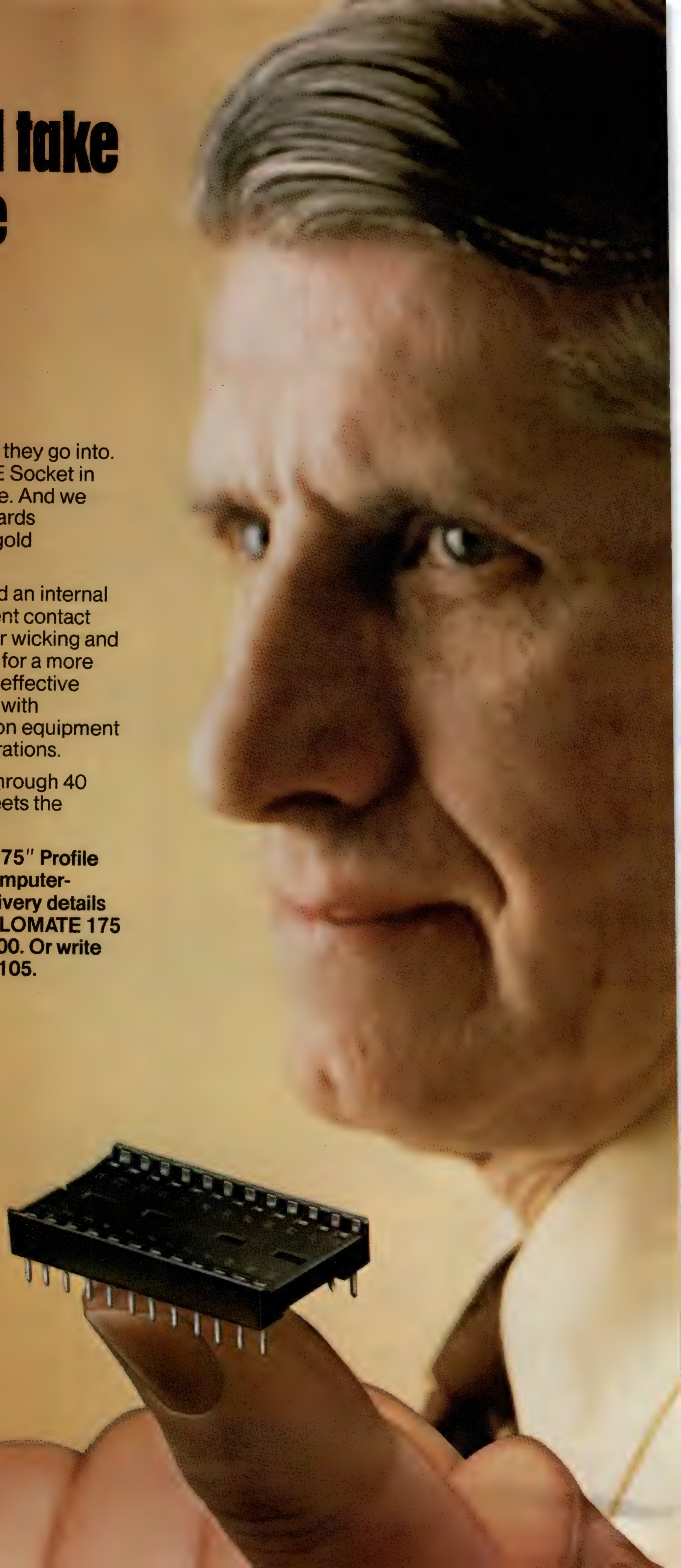

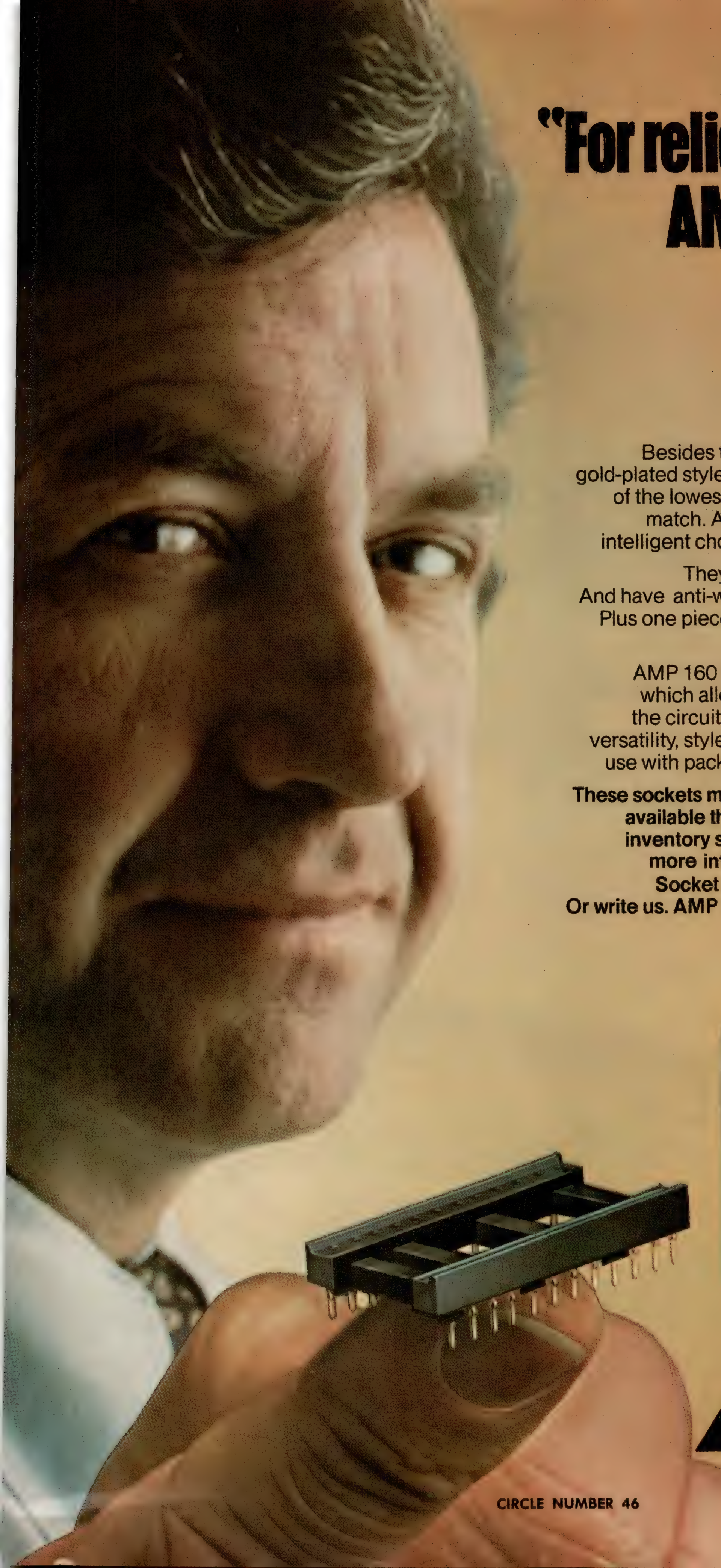

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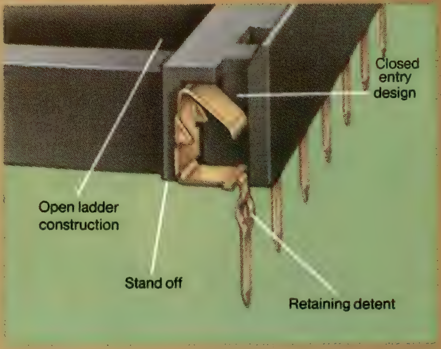

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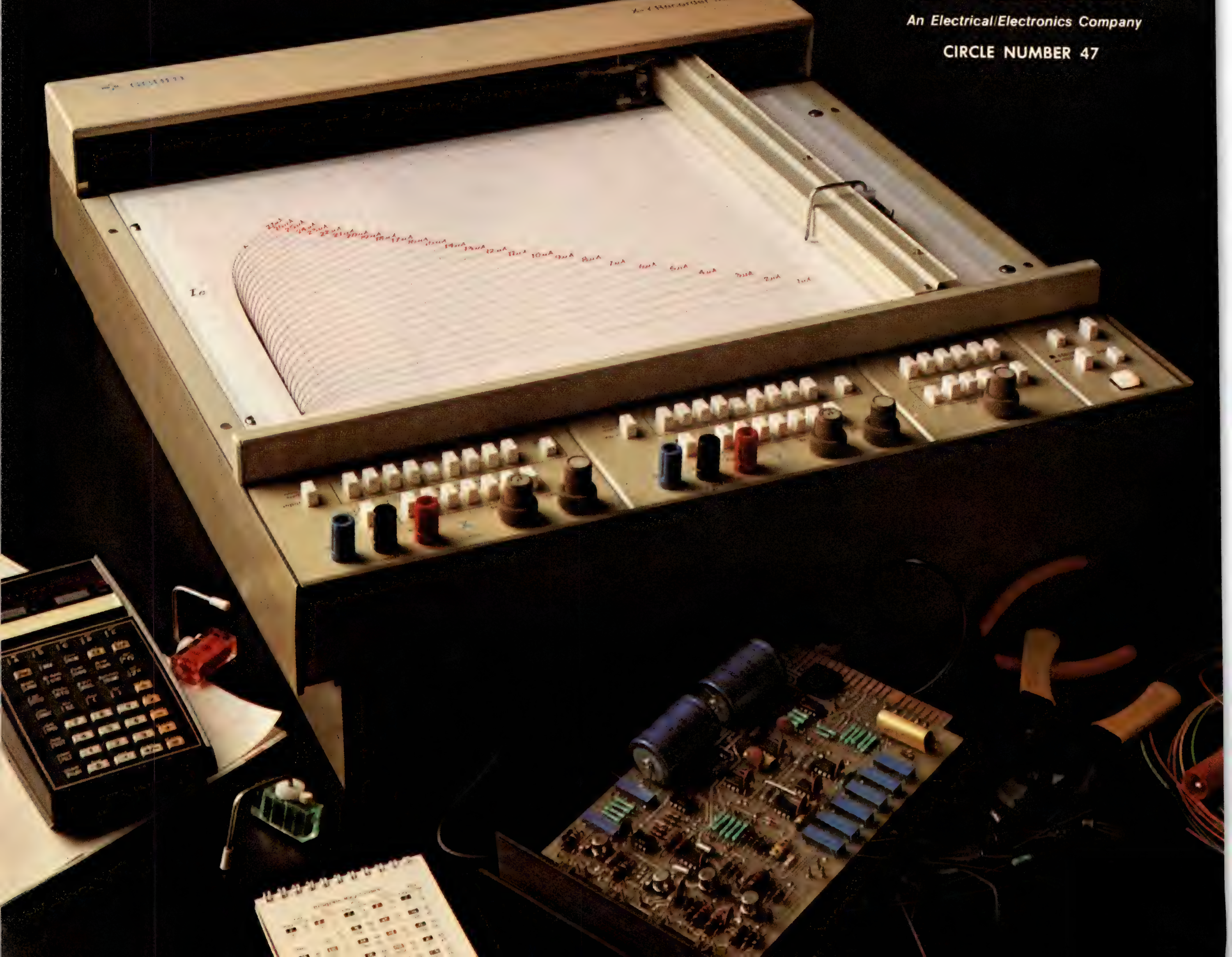

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CIRCLE NUMBER 49 FOR DEMONSTRATION

CIRCLE NUMBER 50 FOR ADDITIONAL INFORMATION

High-frequency switchers get the nod when top performance counts most

Putting principles into practice, this concluding article on high-frequency switching supplies implements the theories discussed in the first three articles of the series to develop several switchers that operate above 200 kHz. Each circuit shown is constructed to satisfy requirements difficult to meet with lower-frequency power supplies.

High-frequency switching power supplies are frequently born out of a need to upgrade supply operation in order to keep pace with component improvements. For example, a high-frequency inverter could result from efforts to build a more efficient 600-kHz sonar-transducer driver (Fig. 1). What's more, this could be just the beginning. High-frequency supplies beget additional high-frequency supplies.

Low-frequency (50-kHz) transducers driven by square-wave inverters used to be the norm, but the arrival of 600-kHz transducers demanded a new drive method. Class-B rf amplifiers originally filled that role, but proved to be inefficient. Fig. 1 shows a special inverter output circuit designed to drive high-frequency transducers.

Fig. 2 contains oscilloscope photos of the collector waveforms, taken with the circuit driving a 100-W resistive load (the driver was actually tested up to 150 W). As Fig. 2a shows, the quality of the output waveform is excellent—the discontinuity in the middle of the rise and fall portion results from a small deadband in the drive. Rise time is just 40 ns. Interestingly, the stray inductance inherent in the circuit is enough to delay the current rise, so there is no turn-on loss.

Transistor Q_1 has a turn-on time in the range of 10 to 15 ns (Fig. 2c), while its turn-off time is only 100 ns (Fig. 2d). Despite the circuit's high operating frequency, efficiency is measured at about 92%. One reason for the high efficiency is that switch losses are moderate—another is that all other circuit losses are quite small (see the table "Switching Losses—600-kHz Inverter").

The output transformer is an 18 × 11-mm ferrite pot core using Magnetics' F-material. However, a 0.5-mil superpermalloy tape core also works very well.

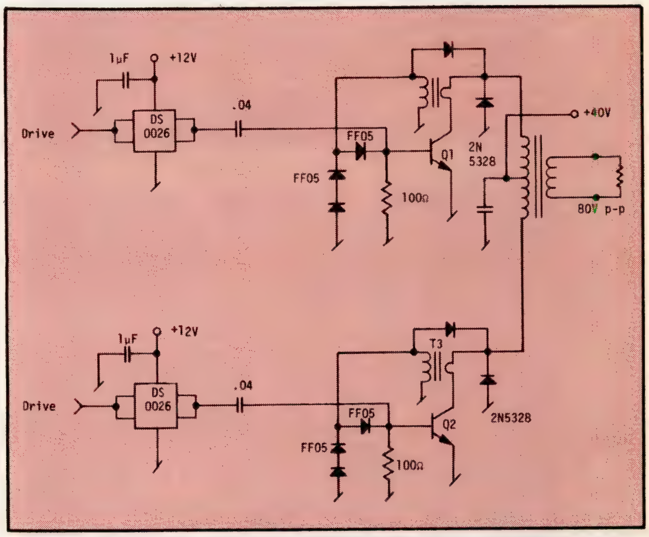
As it turns out, the development of the sonar-drive switching regulator is just the first step in building higher power and more functional circuits.

One switcher begets another

After the 600-kHz driver comes a 200-W, 300-kHz boost converter, designed to test operation at higher power levels. Even though the circuit of Fig. 3 uses a more complex drive scheme than that of Fig. 1, circuit performance improves only marginally.

Because of its higher power output, the switching transistor of the 300-kHz converter has a rise time of 100 ns, a fall time of 70 ns and a storage time of 80 ns. Switching losses are largest— about 5 W—at turn-off. But overall efficiency is 90% for a 22-V input and a 50-V output.

With the success of the 300-kHz converter, it becomes apparent that power supplies can operate effectively at higher-than-normal frequencies. And



1. A 600-kHz inverter designed to drive sonar transducers has an output stage that features fast switching times and high efficiency. Losses in the transistor switches and other components are very small.

Rudolf Severns, Power MOSFET Applications Manager, Intersil, Inc., 10710 N. Tantau Ave., Cupertino, CA 95014.

the need for this type of high-frequency supply is exemplified by its use in a special application: a satellite-navigation-receiver power supply that must have minimum weight (as indicated in previous articles in this series, high-frequency switchers fill this low-weight need perfectly).

But there is an even more important reason to use a high-frequency supply in a receiver application. The receiver's i-f circuits operate in a region of 20 to 40 kHz, where they are sensitive to μV-level signals. Therefore, the power supply's switching frequency must be well above the i-f frequencies.

The 300-kHz supply designed for this application (see the block diagram of Fig. 4) has two output converters—one operating during normal load conditions, the other operating in standby, when the load is much lighter. Power output from the main converter is 22 W, and 1.5 W from the standby converter.

A quasi-square-wave scheme is used for the output of the main converter, and aside from the high switching frequency, the output circuit is quite conventional. Details of the output configuration are shown in Fig. 5.

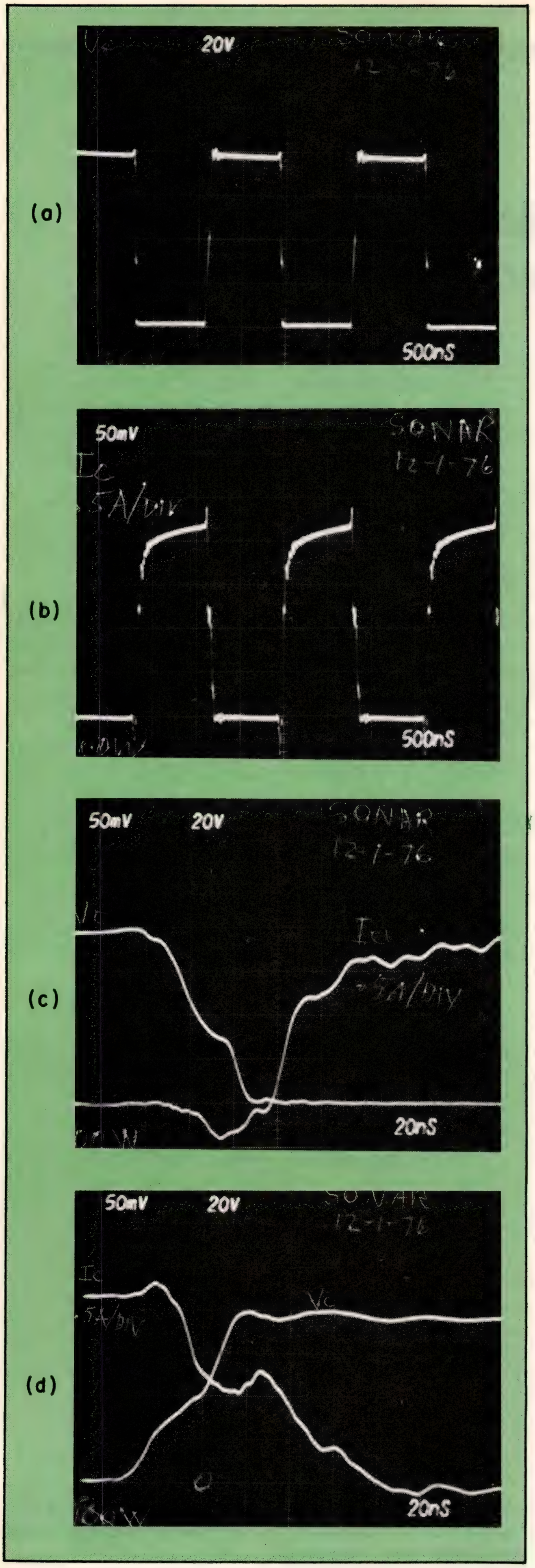
Transition times of the switching transistors are very good— turn-on takes about 10 ns, and turn-off about 20 ns. The converter delivers five output voltages: two +12-V, two −12-V and one +5-V. By far the largest current must be delivered by the 5-V output —a maximum of 3.4 A—but regulation is not very critical, being ±4%. On the other hand, the maximum current drawn from the 12-V outputs is 0.16 A, but regulation must be held to a tight ±1%.

Regulation held up

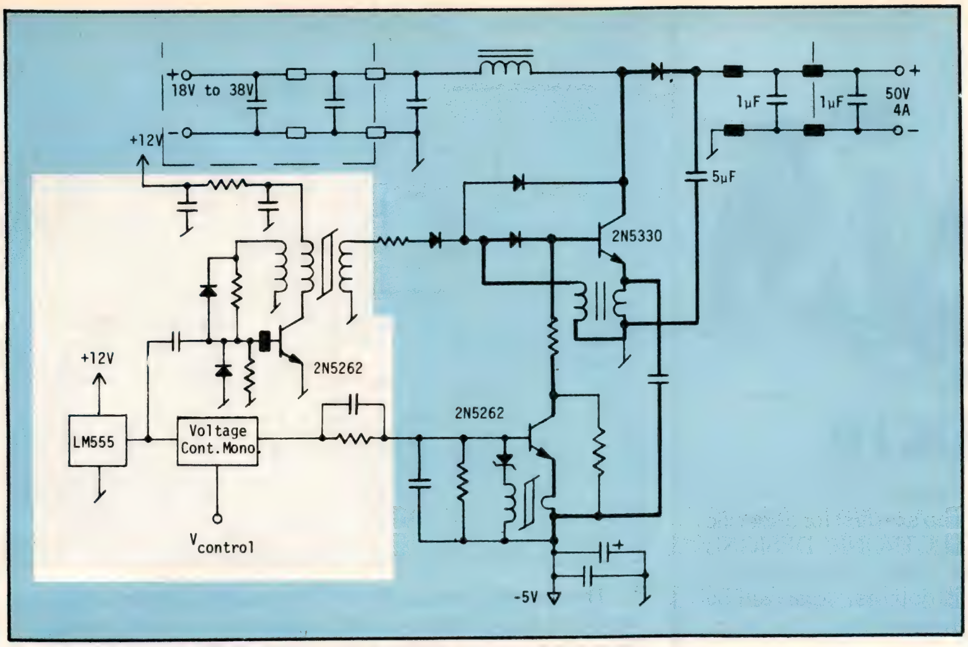
One concern with power supplies of this type is that regulation degrades on the unsensed windings. For this particular supply, however, that concern is not warranted.

Switching losses— 600-kHz inverter

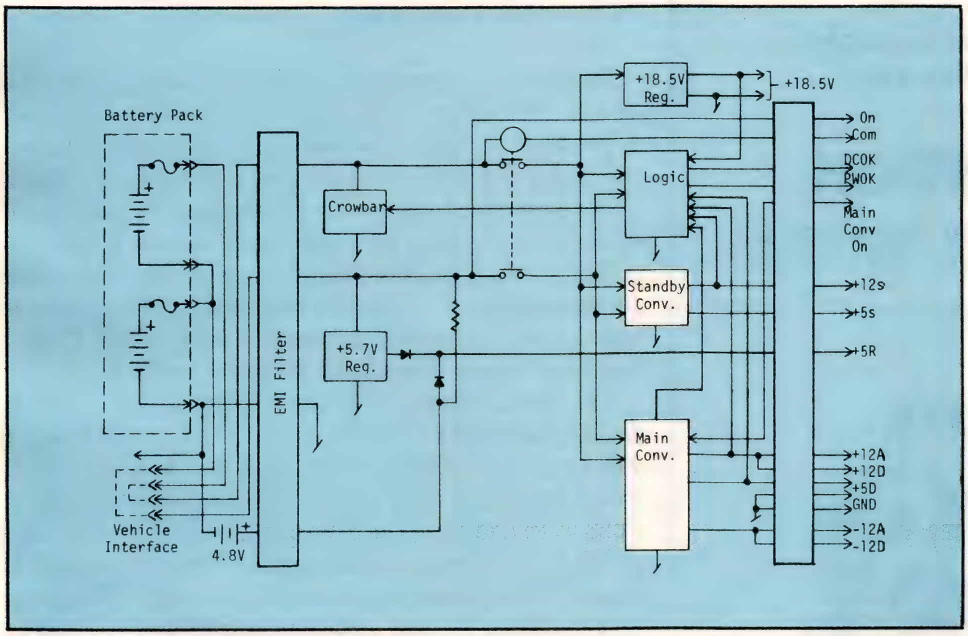
Loss mechanism	Power loss
Turn-on transition	0
Turn-off transition	3.0 W
Collector saturation	1.6 W
Base drive	0.4 W
Total	5.0 W



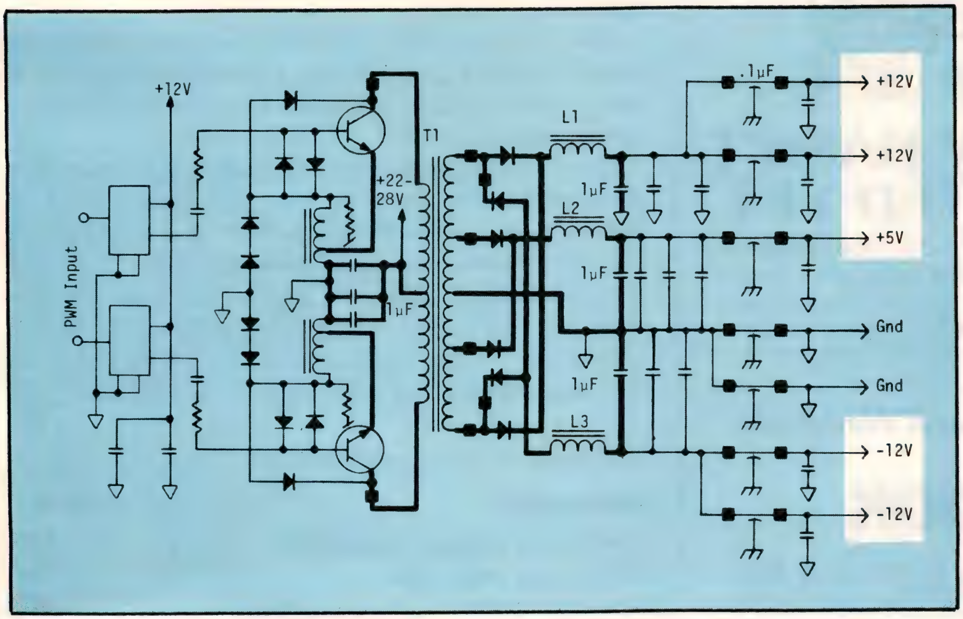
2. Output waveforms of the inverter in Fig. 1 are generated with the circuit driving a 100-W resistive load. The collector voltage and current of transistor Q_1 (a and b) show little discontinuity. Switching times for Q_1 (c and d) are fast for a bipolar transistor—10 to 15-ns turn-on, 100-ns turn-off.



3. Power supplies like this 300-kHz boost converter serve as transition designs in the development of high-frequency switchers. For example, a more complex drive scheme in this circuit does not lead to much better performance than provided by the circuit in Fig. 1.



4. Many high-frequency switchers are built to operate in specific applications. The converter shown powers a navigation receiver—its high frequency (300 kHz) is far enough away from the receiver's i-f (20 to 40 kHz) to prevent interference.



5. The output section of the supply in Fig. 4 is a quasi-square-wave design that delivers five output voltages. This type of switcher often has regulation problems unless the outputs are constantly monitored. But experiments under all variations of line-voltage and temperature extremes prove otherwise.

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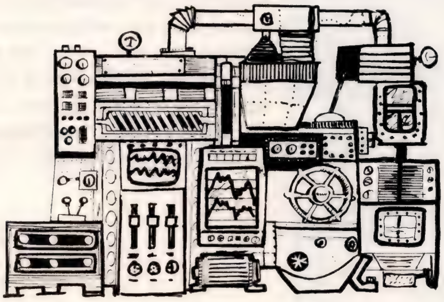

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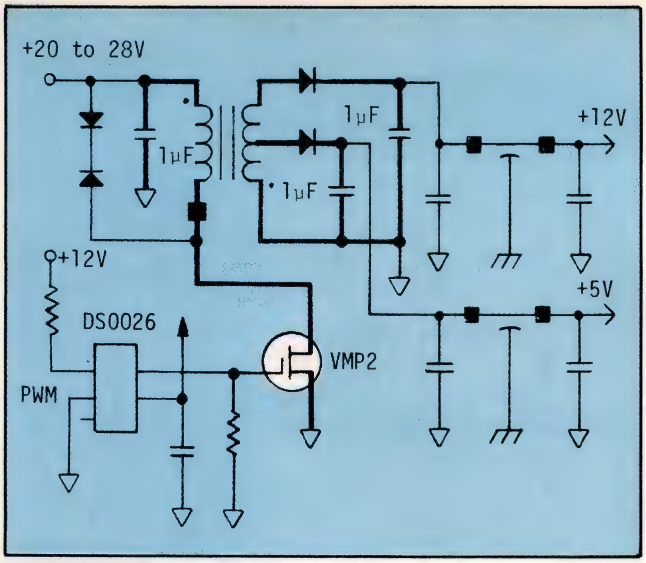

6. The standby converter of Fig. 4 is a low-power unit used to supply the circuitry under reduced load conditions. Providing just a 1.8 W output, the circuit's regulation is ±2% on the 5-V output line.

In the main converter, a feedback loop samples one of the 12-V outputs. To prove that regulation is not a problem in the unsensed outputs, regulation envelopes were generated for the remaining voltages.

A worst-case load profile is produced by placing all loads at max, then reducing each, one at a time, to a minimum. Next, the loads are set at minimum, and increased one at a time to maximum. The profile is run at every temperature over −40 to +100 C, and for line-voltage variations from 22 to 28 V.

For the unsensed 12-V output, the % regulation is nearly constant at −0.25% over the 22 to 28-V range. For the −12-V output, regulation comes out to about 3% at 22 V, and improves to slightly better than that at 28 V. In addition, the 5-V supply's regulation is ±4% at 22 V, and keeps improving as the line voltage is raised, finally reaching about ±3.5% at 28 V. This kind of regulation is very good, as might be expected in a 20-kHz switcher.

The 1.8-W standby converter is a 600-kHz buck-boost circuit (Fig. 6). While a power MOS device is used as the switch, a bipolar transistor could have served nearly as well.

The circuit has some current ringing at turn-on, but this can be eliminated by placing a ferrite bead on the drain load of the MOSFET. Note that even though the buck-boost converter does not have the best multiple-output regulation performance at low frequencies, the output regulation of this supply is still very good. Voltage regulation on the 5-V output, with the loop sensing the 12-V output, is ±2%.■■

How useful?	**Circle No.**
Immediate design application	**559**
Within the next year	**560**
Not applicable	**561**

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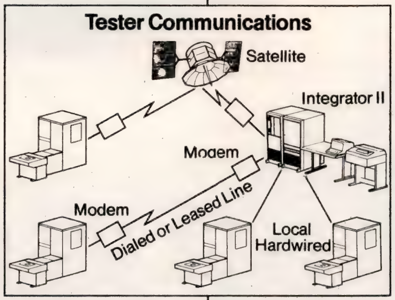

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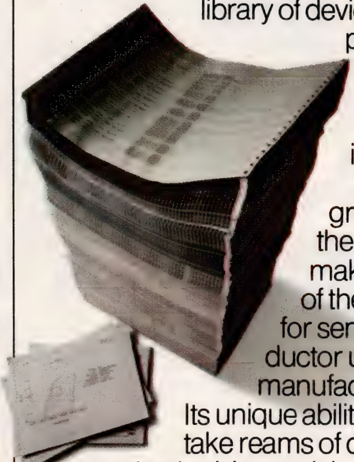

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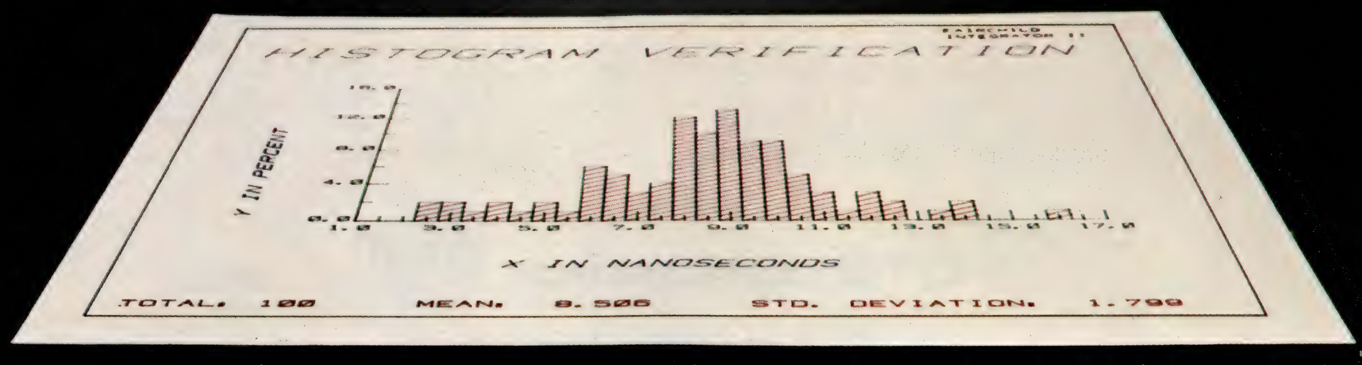

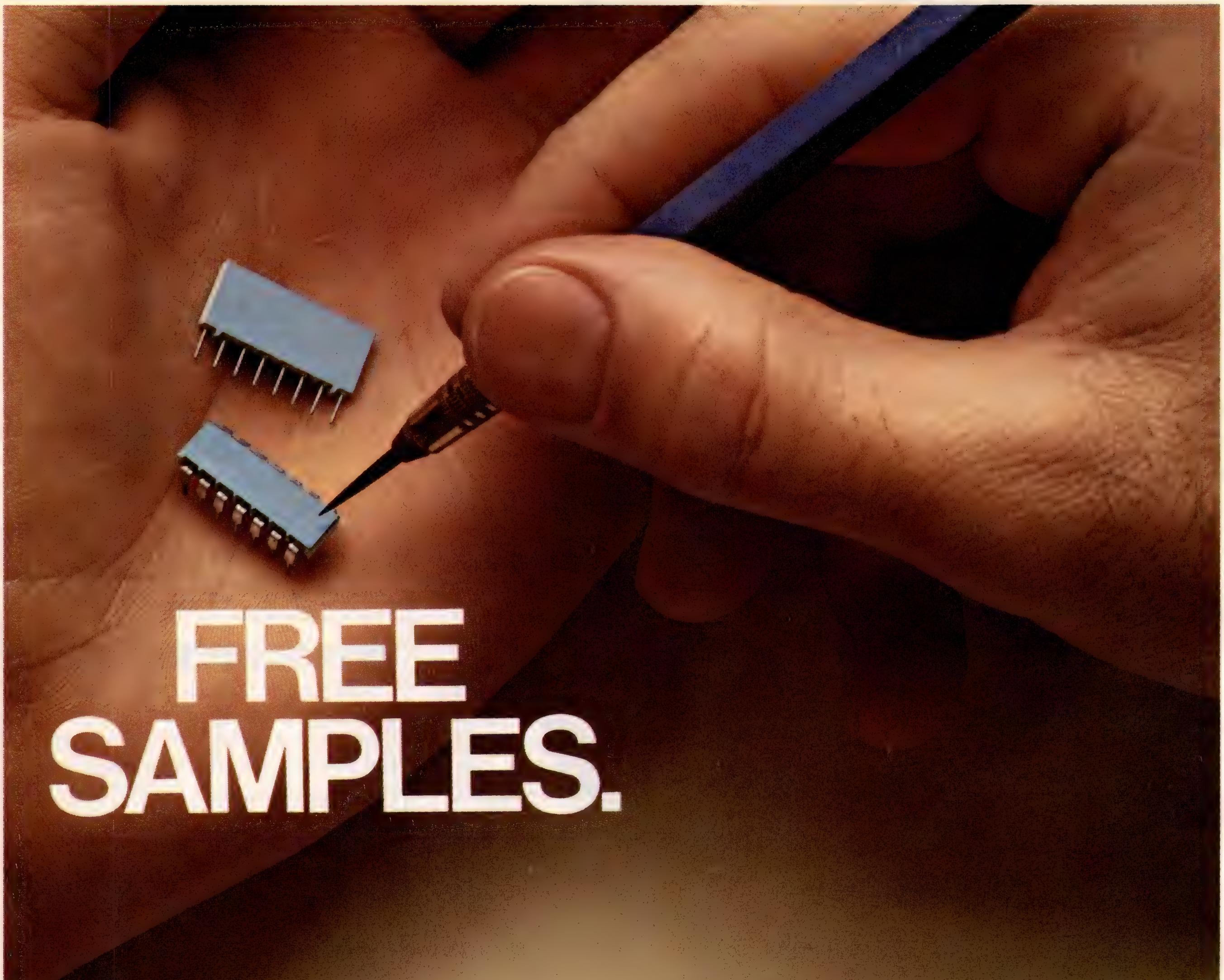

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Tristrobed transconductance amplifier improves rate-limit sensor's noise immunity

A CA3060 tristrobed transconductance amplifier greatly improves the noise immunity of a rate-limit-sensor design originally based on the CA3080 op amp. That design appeared in ELECTRONIC DESIGN, Jan. 18, 1980, p. 114. The improved design (see Fig.) retains the TL084 quad op-amp chip and the ability to work with slowly changing analog voltages while, again, eliminating the need for large capacitors.

The required ±7.5-V strobe pulses (more than 3 μs long) can be obtained essentially "free of charge" from the clock outputs of most automotive or industrial systems needing rate-limit sensors. The clock can be divided, time-truncated and level-shifted as necessary.

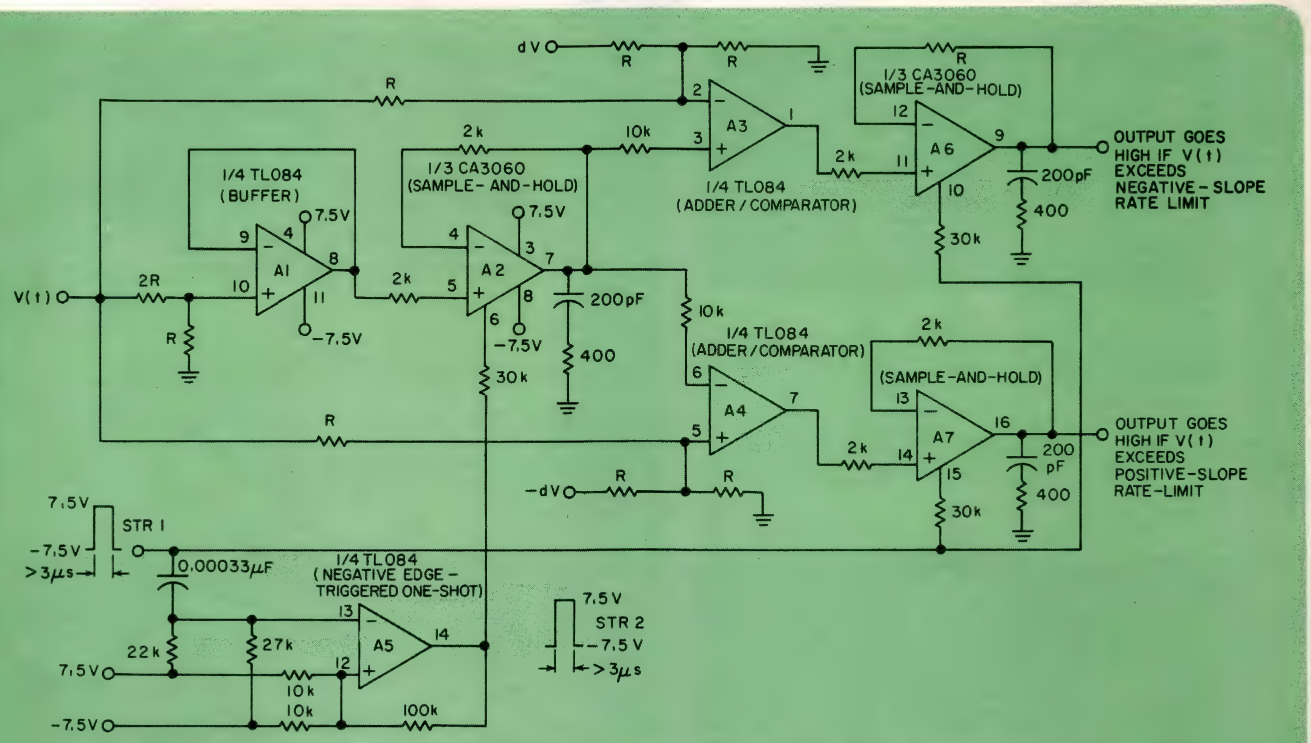
Let V(t) be the voltage representation of the monitored parameter, and let it vary between some minimum value, more positive than −7.5 V, and some maximum value, less positive than 7.5 V. When strobe pulse STR 1 occurs, A_6 and A_7 sample the outputs of A_3 and A_4, respectively. If A_3 is high, indicating a negative-slope rate-limit violation, the A_6 output will clock high. If A_4 is high, indicating a positive-slope rate-limit violation, the A_7 output will clock high.

Note that A_6 and A_7 are approximations of D flip-flops—only because they are not exactly edge-triggered but require a finite-width enabling pulse (as opposed to the ideal D flip-flop with a clock time approaching zero). Therefore, to prevent the A_2 update from interfering with the accuracy of the information transferred to the A_6, A_7 outputs, another strobe pulse, STR 2, must be generated for A_2.

Note also that the system is vulnerable to noise only during the (roughly) 3-μs sample times provided by STR 1 and STR 2. But because this clock time is small compared to the interstrobe time, the system is essentially immune to noise.

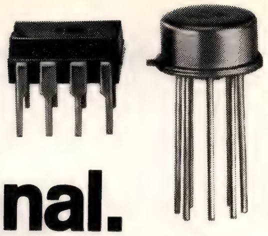
John Cyril P. Hanisko, Project Engineer, Bendix, 900 W. Maple Rd., Troy, MI 48084.

CIRCLE NO. 311



This improved rate-limit sensor is vulnerable to noise only during the (roughly) 3-μs sample times provided by STR 1 and STR 2. An output (from A_6 or A_7) is provided only if V(t) exceeds preset rate-of-change limits. Slow rates-of-charge are easily monitored without using large capacitors.

BiMOS vs. BiFET op amps: The RCA alternate source for TI's 080 outperforms the original.



Our new CA080 BiMOS series is a pin-for-pin compatible alternate source for the TL080 BiFET family from Texas Instruments.

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Your filter circuits will cost you less because you can increase resistor values and use less expensive, lower value capacitors.

The lower input bias and input offset currents of our devices also let you design circuits with input signal currents in the picoamp range.

Other features of the new CA080 series are: low power consumption, wide common mode input voltage range, fast slew rate, 5.0 MHz (typical) bandwidth, low distortion, and large output voltage swing.

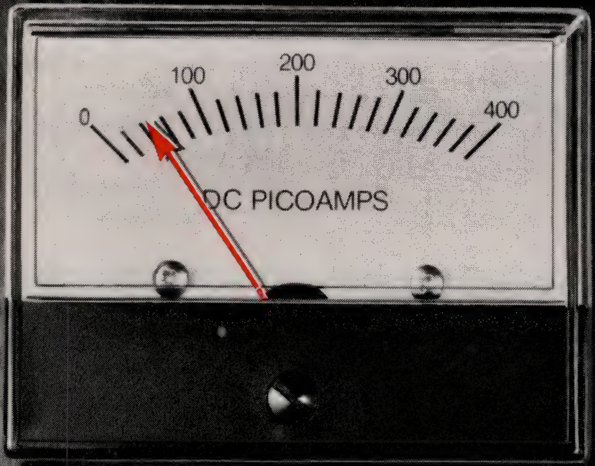
The CA080 and CA081 single devices are available in quantity now. Our CA082 and CA083 duals will be available by mid-1980.

For more information, contact your local RCA Solid State Distributor.

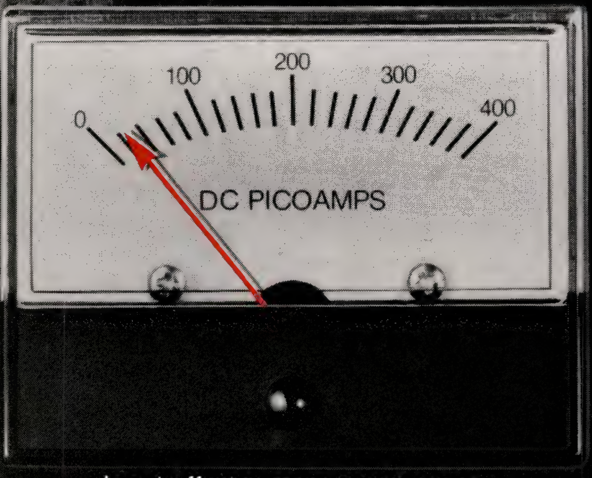
Or contact RCA Solid State headquarters in Somerville, New Jersey. Brussels, Belgium. Tokyo, Japan.

CIRCLE NUMBER 53

RCA
BiMOS op amp:



Input bias current (25° C.): 50 pA.



Input offset current (25° C.): 30 pA.

TI
BiFET op amp:

Input bias current (25° C.): 400 pA.

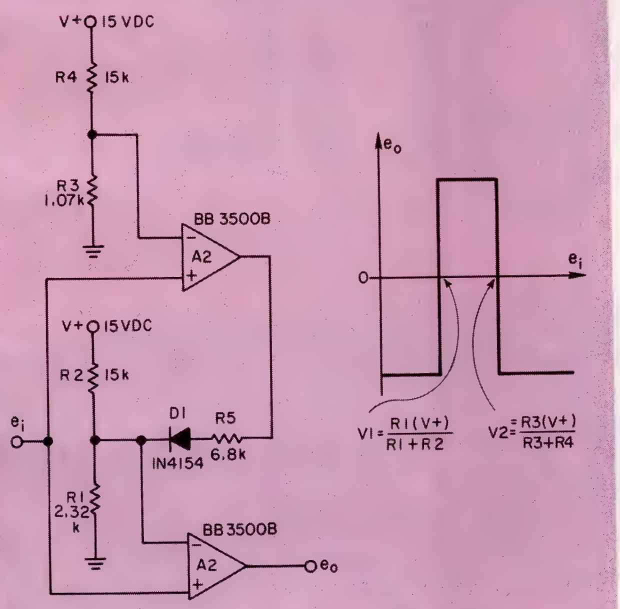
Input offset current (25° C.): 200 pA.

RCA

Two op-amp window comparator needs no output decoding

This two op-amp window comparator exhibits precise boundary accuracy yet needs no output decoding. A diode interconnection between the op amps forces one amplifier output to execute both window transitions. This arrangement (see Fig.) eliminates the digital circuits needed by other window comparators.

A window comparator indicates whether a signal is within a given voltage range: Signals within the defined range produce a high comparator output state; a low output state results when signals fall outside the range. An important application of the circuit is in go/no-go testing for checking whether a system or circuit is operating within a given range of performance.



Arranging the op-amps of a window comparator so that one switches the threshold of the other removes the need for digital output decoding. Boundary accuracy can be kept within ±0.002%.

In typical window comparators, the output signals of two comparators are digitally combined to produce the window output. However, the design detailed here uses op-amps as comparators, and the voltage dividers formed with R_1 through R_4 set the two switching thresholds. By means of the R_5/D_1 connection, one amplifier output is forced to make both window transitions.

The amplifier outputs of both A_1 and A_2 are low for negative input signal (e_i) levels. As e_i moves positive, it reaches the V_1 threshold (set for A_1 by R_1 and R_2) first. At this point, output e_o switches from a low to a high state. It remains there (as e_i continues to increase) until the V_2 threshold (set by R_3 and R_4) is reached. Then the output of A_2, driving the inverting input of A_1 switches positive, returning e_o to the low state. In effect, A_2 has driven the threshold of A_1 more positive (away from e_i). This new threshold should be set above the range of anticipated e_i signals by choosing an appropriate value for R_5. (Although this resistor could be reduced to zero, a finite resistance lowers current drain).

For the component values shown, the comparator's window boundaries are 1.0 V and 2.0 V. The shifted threshold of A_1 is 5 V. Major limitations to boundary accuracy are resistor and voltage-reference tolerances. Calibration can greatly reduce these factors. Then, the amplifier's input offset voltages and input bias currents become the dominant sources of error (but these too can be compensated for). By this method, residual error is kept within ±0.02%.

Reference

Graeme, J., *Designing with Operational Amplifiers—Applications Alternatives,* McGraw-Hill, 1977.

Jerald Graeme, Manager, Instrumentation Components Design, Burr-Brown Research Corp., P.O. Box 11400. Tucson, AZ 85734.

CIRCLE NO. 312

CSC's Model LM-3 Logic Monitor. It's a new breed of test instrument. Here in a single compact package are *forty* high-speed high-impedance precision-threshold logic state indicators with triggerable latching modes.

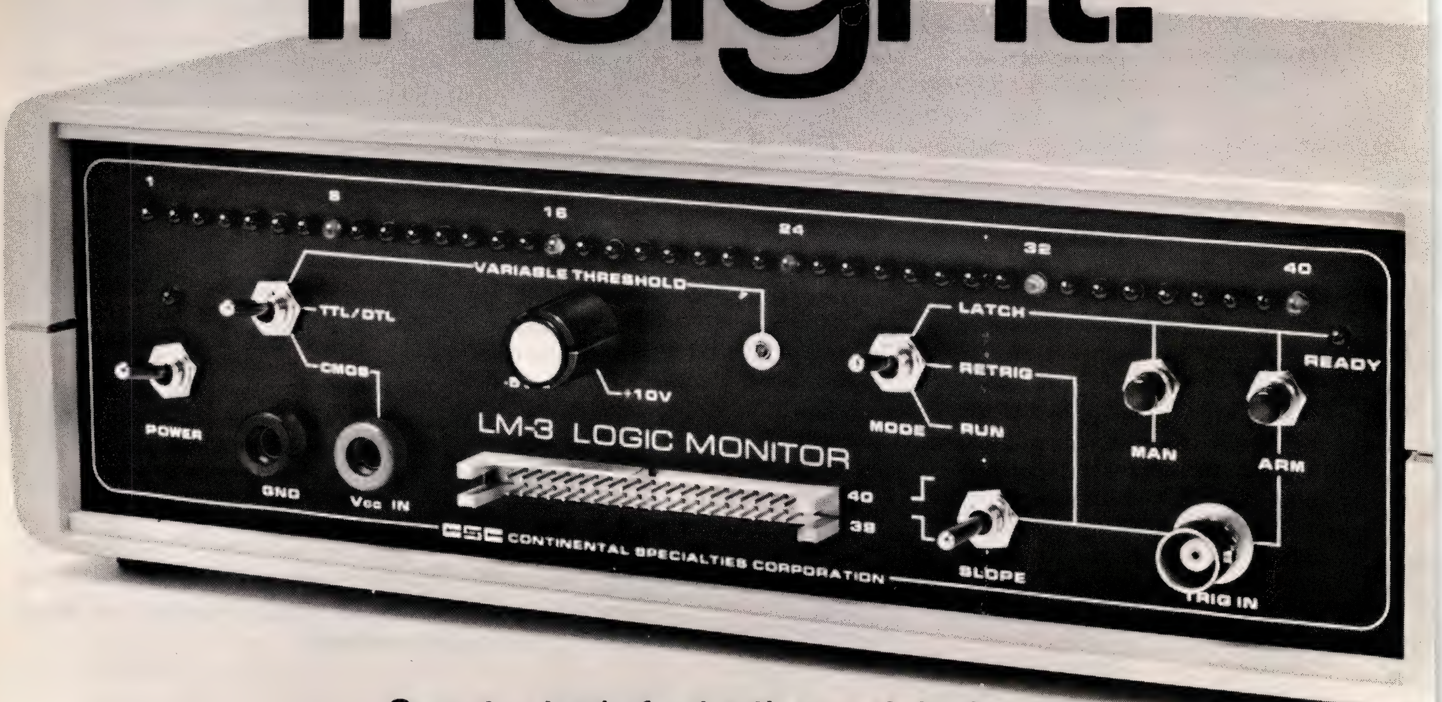
Just connect the LM-3 Logic Monitor to any combination of bus lines, test points, IC pins or other nodes. Pick the operating mode: the LM-3's display follows up to 40 channels of data in RUN; stores and displays 40 data channels when triggered in LATCH; or updates its latched data display with every trigger in RETRIG. There's even a pushbutton to manually latch the display.

The applications are endless. Connect to the pins of a processor, UART, memory—any IC—for device tests. Follow the action of a logic tree by connecting to selected gates, flip-flops, registers, etc. Monitor up to 40 bus lines, checking data, address, I/O, flags—anything digital. Choose 40 test points on a single board, or perform side-by-side comparisons with a known-good board.

More? More than we have room to tell. Compatibility with past, present and future logic families from ECL to TTL to CMOS. Constant input impedance at every threshold level. 5 MHz channel response. A comprehensive instruction/application manual as innovative as the instrument itself. Plus cables and connectors to make the package complete.

40 logic channels. Triggerable memory. And more. At $585*, it's probably underpriced. Call now and get the full story.

Insight.



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CIRCLE NUMBER 54

TV color-burst crystal generates clock and interrupt signals for μP

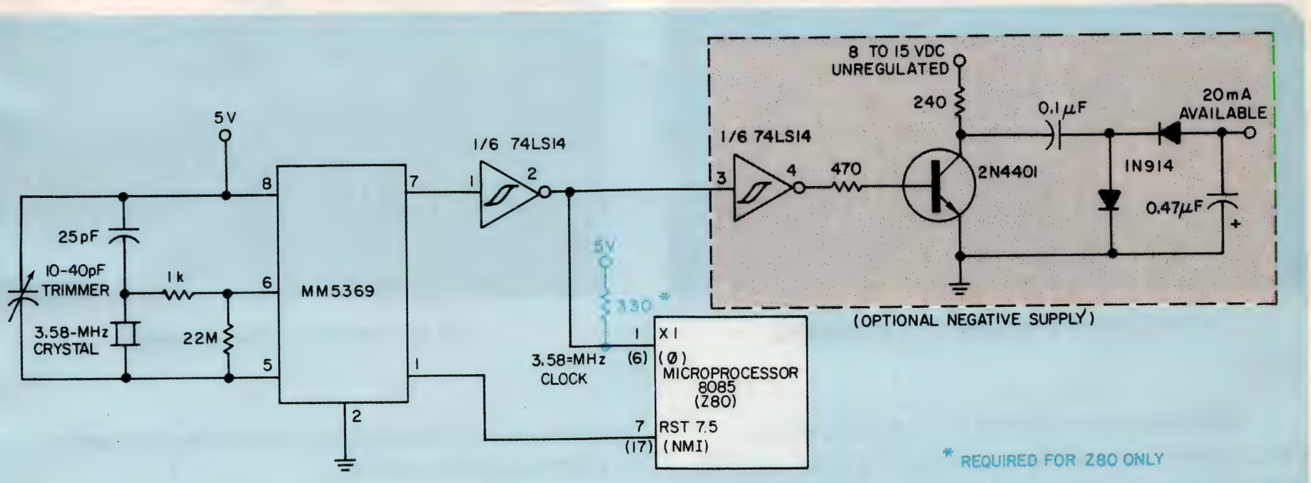
An inexpensive TV color-burst crystal (3.579545 MHz) drives an MM5369 CMOS programmable oscillator/divider to establish the proper clock and interrupt signal levels for the Intel 8085 or Ziolog Z80 microprocessor. An optional negative supply voltage may be derived from the clock output using a few additional components.

With the circuit shown, the microprocessor is supplied with a single-phase clock at the fundamental frequency of the color-burst crystal. A 60-Hz real-time clock interrupt handles software timekeeping functions. Only a small modification (shown in color) is needed to adapt the circuit from 8085 operation to Z80 operation. Other microprocessors could be used that require a similar single-phase clock and edge-sensitive interrupts.

The optional negative power supply (shown in the dashed box) is for use with small, dedicated controllers that are typically powered from a single, regulated, supply voltage. This extra feature can provide enough current (20 mA) for an RS-232 interface. With the addition of a 7812 12-V regulator and a 7905 5-V regulator (not shown), the optional supply could deliver the supply voltages needed for a single 2708L EPROM.

Ken Barbier, Electrical Engineer, Borrego Engineering, P.O. Box 1253, Borrego Springs, CA 92004.

CIRCLE NO. 313



A single-phase clock at approximately 3.58 MHz and a 60-Hz clock interrupt signal—suitable for 8085 or Z80 operation—can be derived from an inexpensive TV color-burst crystal. The optional negative supply provides up to 20 mA for additional circuits (such as the RS-232 serial interface) commonly used with dedicated microprocessor systems. The single modification (color) is for Z80 operation.

IFD Winner for December 6, 1979

Irving Simon, Electrical Engineer, Clay Adams Div. of Becton Dickinson Corp., 299 Webro Rd., Parsippany, NJ 07054. His idea "Glitch Catcher Finds Noise, Transients in Logic Circuits" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Reader Service Card at the back of this issue.

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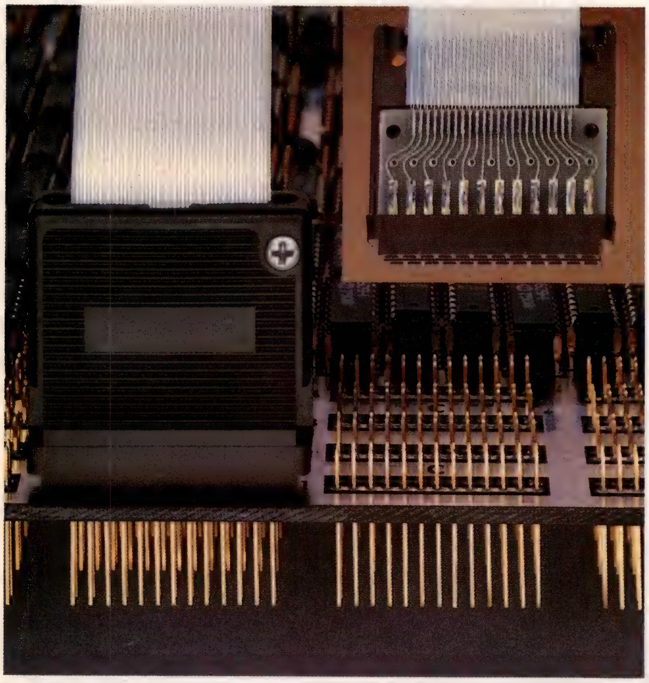
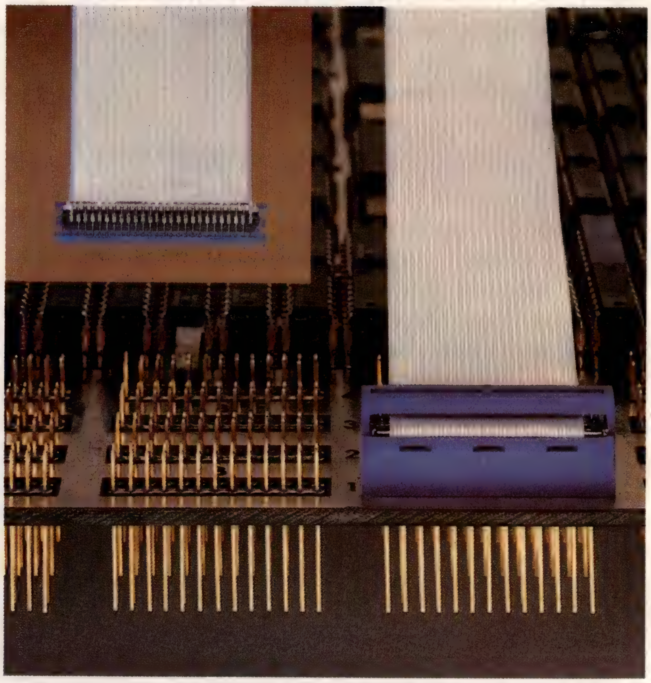
ELECTRONIC DESIGN cannot assume responsibility for circuits shown nor represent freedom from patent infringement.

Berg's TLC* connector terminates transmission line cable without a paddleboard.



Paddleboard assembly–the slow way.



"TLC" connector–the fast way.

Assembly time and the cost of terminating transmission line cable are significantly reduced with Berg's unique "TLC" connector system. Completely eliminating the need for a paddleboard, the "TLC" connector reduces cable assembly time to seconds.

The connector's compact size provides greater signal fidelity and facilitates high-density packaging.

"TLC" connectors terminate any cable with signals on 0.050'' centers. The ground wires are commoned on the buss bar allowing use of a wide range of cable designs with a variety of ground centers and diameters. Pre-deposited solder on the buss bar and signal tabs allow for mass reflow. This produces higher yields and further reduces assembly cost.

The "TLC" design uses Berg's proprietary PV* receptacle, a connector of proven reliability for over a decade in data processing applications. The dual-metal construction of the "PV" provides a high normal force to assure highly reliable mechanical and electrical performance.

"TLC" connectors mate with 0.025'' pins or standard Berg headers on 0.100'' grid to form a complete interconnection system.

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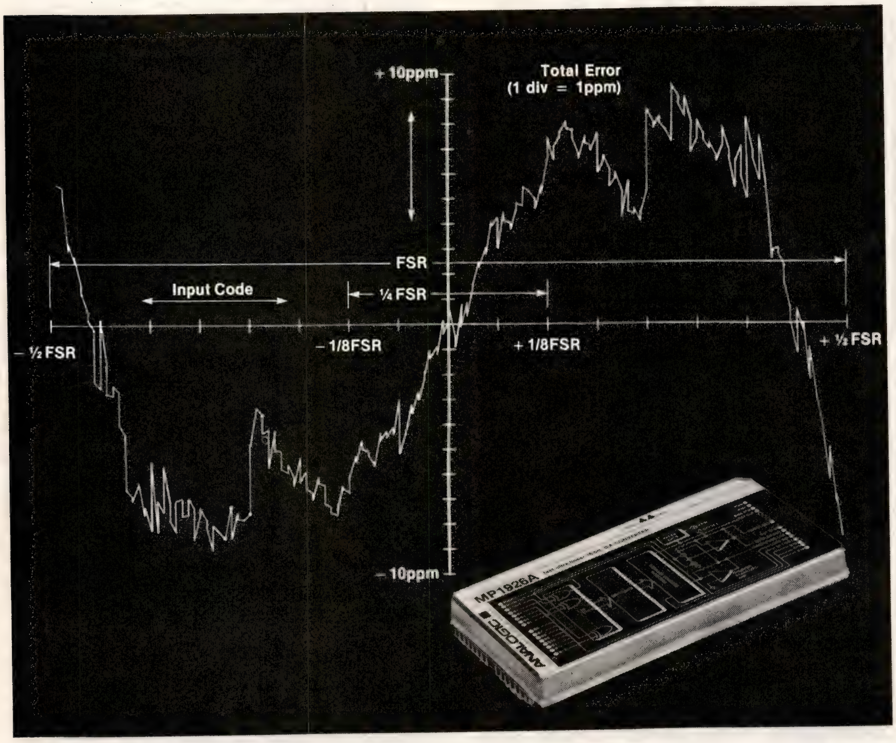
CIRCLE NUMBER 55

Modular d/a converter reproduces audio free of distortion



Analogic Corp., Audubon Rd., Wakefield, MA 01880. Dick Ferraro (617) 246-0300. P&A: $198; stock to 4 wks.

A digital-to-analog converter, designed by Analogic specifically for reconstructing complex dynamic waveforms from digital data, offers exceptional small-signal performance for audio-frequency applications. Because acoustic, audio and sonar signals contain considerable information in the vicinity of 0 V (midrange), the MP-1926 bipolar module, in fast and slow versions, employs an internal sign/magnitude architecture to reproduce these analog waveforms without crossover distortion.

While most DACs of this type use an offset binary design, the sign/magnitude architecture offers better performance, particularly as the input signal approaches zero from either direction. The transfer function of an offset binary converter originates at a minus full scale (all current switches off), and 0 V is usually 1/2 FSR. Any subsequent gain drift shifts the output significantly at 0 V. But with sign/magnitude, the transfer function originates at 0 V, and is virtually unaffected by gain drift.

For signals around 0 V, the fast 1926A performs with 18-bit linearity and 3-μs settling for a 5-V step to 0.01%. Midrange linearity, centered around 0 V (±1/8 FSR), is specified at ±4 ppm, which is just ±1/4 LSB. This means that the module is capable of providing a full 96 dB of usable dynamic range (2^{16} voltage steps). Moreover, total full-range harmonic distortion—measured with an external deglitch amplifier at the output—is better than 0.005%, or 0.0005 dB.

For operation in professional audio systems, the 1926 can handle signals at a 50-kHz rate. Thus, one d/a module can be time shared between two audio channels. Because of its frequency characteristics, another application is vibration analysis.

The slower 1926S is optimized for reference applications, and offers more stable operation than the A-version. Voltage offset, linearity and gain drifts are so low that the worst-case total effect (algebraic sum) near 0 V is typically less than 1 ppm/°C over 0 to 70 C. Temperature coefficient of offset voltage at 0 V is at most ±0.5 ppm of FSR/°C. Settling time, however, is 40 μs to 0.01% of a 5-V step.

Both versions sport an auxiliary unipolar output that not only is proportional to the magnitude of the bipolar output but also offers a 0-V offset stability of 1 μV/°C. In addition, the modules accept offset binary, two's-complement and sign/magnitude input codes from either TTL or CMOS logic. This allows simple interfacing with most computer-based systems.

Thanks to the sign-magnitude approach, both versions withstand drift caused by on-board resistor networks. Most networks have tracking ratios worse than 15 ppm/year that, in offset binary converters, cause significant linearity drift around 0 V. But a sign/magnitude converter can be expected to be four or five times less sensitive to resistor drift problems. Long-term linearity stability of the 1926 is predicted to be better than 1/2 LSB per year.

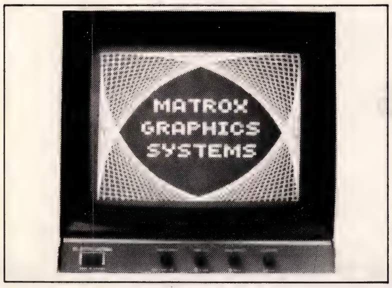
Operation—from −25 to +85 C, in all—is from a single bipolar power supply, ±8 to ±15 V, with ±16-mA capability. Rated performance is over the range 0 to 70 C. Because full-scale range is pin-programmable, 20-V FSR, for one, requires a ±15-V supply. Power consumption for the metal-cased modules is at most 250 mW with a ±8-V supply, and 500 mW with a ±15-V supply, not counting any external loads.

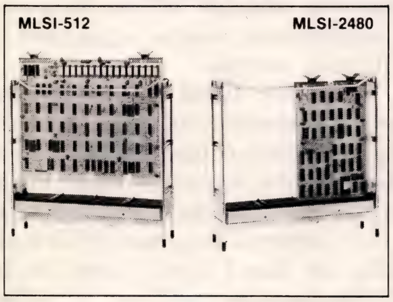
CIRCLE NO. 301

Gene Heftman
Field Bureau Editor

matrox

PDP-11 and LSI-11 bus displays





MATROX has the most complete line of CRT display boards for DEC's PDP-11 and LSI-11 bus in the industry. We have alphanumerics; graphics; color; black and white; variable resolution; external/internal sync; 50/60 Hz; software and much, much more. Just plug the board in any PDP/LSI-11 bus connect video to any standard TV monitor, and presto, you have added a complete display to your system at a surprisingly low cost.

LSI-11 BUS

MLSI-2480	24 x 80 alphanumerics
MLSI-256	256 x 256 dot graphics
MLSI-512 x 256	512 x 256 graphics
MLSI-512	512 x 512 graphics
MLSI-1024	1024 x 256 graphics

PDP-11 BUS

MDC-2480	24 x 80 alphanumerics
MDC-256	256 x 256 dot graphics
MDC-512 x 256	512 x 256 graphics
MDC-512	512 x 512 graphics
MDC-1024	1024 x 256 graphics

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CIRCLE NUMBER 56

One analog control minds three servo motors

Signetics Corp., 811 E. Arques Ave., P.O. Box 409, Sunnyvale, CA 94086. (408) 739-7700. P & A: 3 to 6 wks.

A universal analog controller, the NE5522N, can precisely control the speeds of up to three separate motors with a single analog voltage input. The 24-pin device, which has on-board memory, can control production applications such as a conveyor-belt system, in which three separate conveyors must run at different speeds but in sync; a change in speed of one conveyor, for example, produces proportional changes in the speeds of the others.

The NE5522N is essentially a frequency-to-voltage converter, coupled to an I^2L logic gate and a d/a converter. Input signals are compared with the output of a built-in reference oscillator and the outputs are adjusted accordingly. A 256-bit memory facilitates accurate comparisons and commands. Three-state buffered open-collector transistor ports provide gating and on-off commands to peripherals. An analog error output is also available for interfacing with linear control systems.

System gain, frequency sensitivity, and ramp rate are adjustable in the controller, and command modes are voltage-programmable. Input pin 3, for example, will register an "off" state with less than 0.094 V at the input, and an "on" state with any voltage greater than 1.1 V. Voltages between 0.094 and 1.1 V, however, can be interpreted by the controller as Set Memory, Compare Memory, Positive Ramp or Memory Erase commands at the same pin.

The manufacturer recommends a supply voltage of 8.2 V, though any voltage between 7.4 and 9 V can be used. Power consumption is minimal, typically less than 20 mA for an 8.2-V supply.

In addition to the NE5522 analog controller, Signetics is bringing out the 5512 and 5514-series op amps, which have no input FETs, but nonetheless provide the high input impedance and high sensitivity of FET amplifiers. Intended for test instruments and analog-amplification circuits, the op amps should prove especially useful in transducer amplification and data-acquisition circuits requiring low drift and low offset voltage, as well as low input bias currents.

The NE5512 dual op amp provides a typical input offset voltage on the order of 1 mV at 25 C. Typical input bias current is on the order of 6 nA, while the input impedance is 100 MΩ. Unity bandwidth for the NE5512 is 1 MHz, while the large signal gain for a 2-kΩ load and an output voltage swing of ±10 V is typically 200. Slew rate is 1 V/μS, which is a good figure for a device with such a small input bias current.

For the NE5512, the output voltage swing with a 2-kΩ load is typically ±13.5 V, and ±11.5 V with a 600-Ω load. Total harmonic distortion is less than 0.01% and the noise at 1 kHz is less than 30 $nV/\sqrt{Hz}$.

A quad version of the 5512, the NE5514, provides the same low input bias currents (6 nA typical), the same low input offset voltage (1 mV typical), and the same high input impedance (100 MΩ). Slew rate is 1 V/μS and its large signal gain is on the order of 200. The output voltage swing is ±13.5 V with a 2-kΩ load and ±11.5 V with a 600-Ω load. Though there are four basic separate amplifiers attached to the same power supply, the power supply current is typically less than 6 mA and invariably less than 10 mA.

Ceramic packaged versions of both op amps are rated for operation from −55 to +125 C, while plastic versions are rated for 0 to 70 C. In addition, the NE5512 is currently available in a plastic DIP package, while the NE5514 is currently available only on a ceramic DIP. The NE5514 will be available later in plastic.

Delivery for current versions of the NE5512 dual op amp and the NE5514 quad op amp is from stock to six weeks. In hundreds, the NE5512 costs $1.00 each; the NE5514, $1.60.

NE5522N **CIRCLE NO. 302**
NE5512, 5514 **CIRCLE NO. 377**

Observe your Z80 or 8085 microprocessors in action with one of our two new analyzers.

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PRO-LOG
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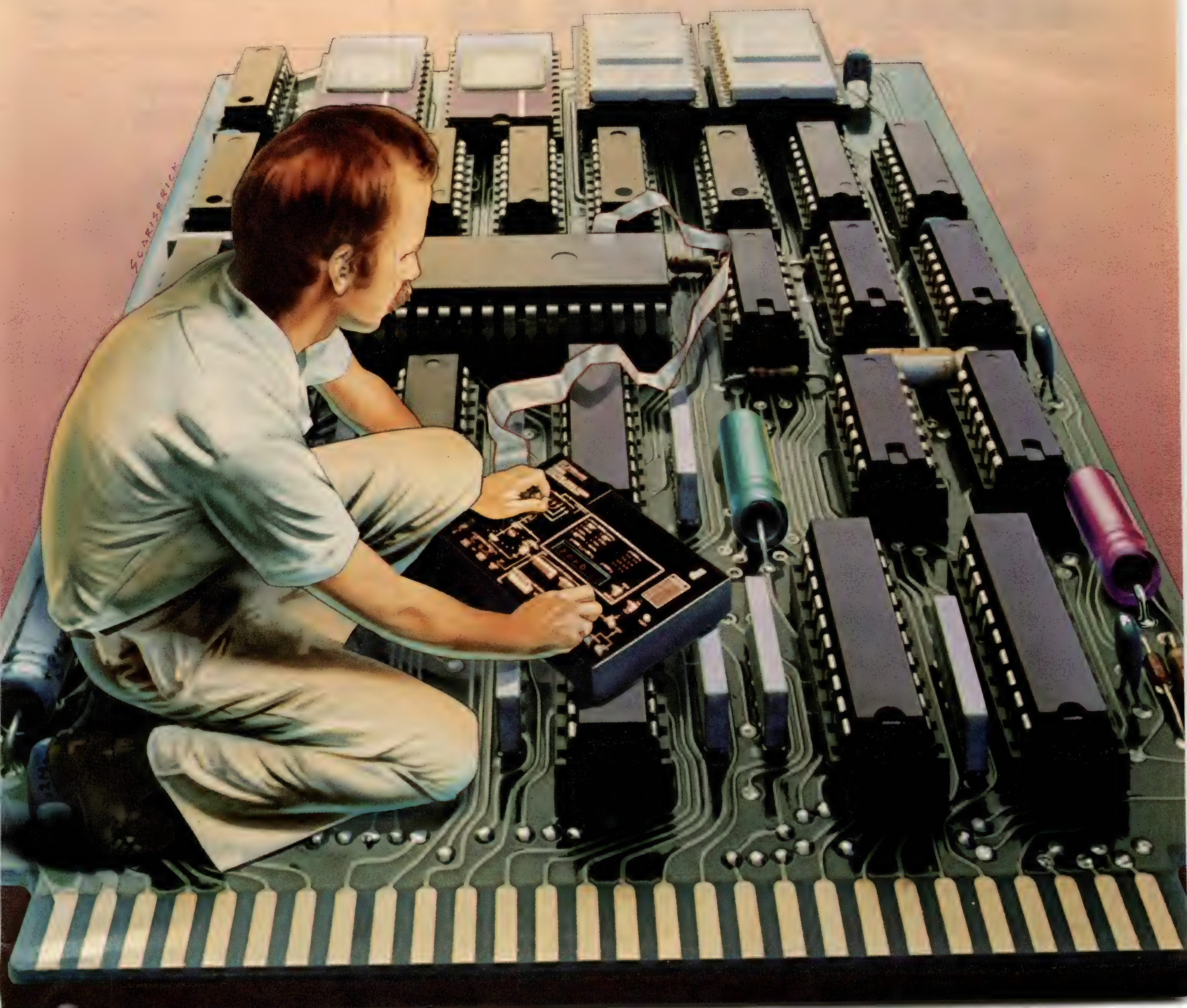
CIRCLE NUMBER 57

Get inside your design with our microprocessor analyzer.



Save the search for reference and op amp—this 11-bit DAC has them

Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050. (408) 246-9222.

End the need for external precision voltage references and output operational amplifiers with Precision Monolithics' 11-bit digital-to-analog converter, the DAC-210. This monolithic device speeds conversions with its 1.5-μs settling time. Nonlinearity, monotonicity and full-scale tempco are guaranteed over the full operational temperature range.

The DAC-210 is a 10-bit device with sign coding for resolution equivalent to an 11-bit binary converter. Polarity of the output is determined by the logic level of the sign bit; the magnitude of the output voltage is determined by the binarily weighted logic inputs. Tying the sign bit to +5 V or to ground allows operation as a straight 10-bit binary converter.

For improved full-scale tempco, the DAC-210 accepts external references. This allows tracking of other system elements or slaving of several DAC-210s to the reference output of any one of them.

DAC-210 operates on supplies ranging from ±12 to ±18 V. Logic-input stages require about 1 μA and are capable of operation over a wide input-voltage range. This allows direct CMOS interface with no added components. The output operational amplifier provides stable operation with capacitive loads up to 500 pF.

Commercial-grade and military-grade devices, two with MIL-STD-883 Class B processing, are available in 18-pin hermetic DIPs.

CIRCLE NO. 303

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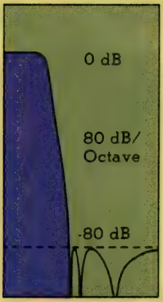

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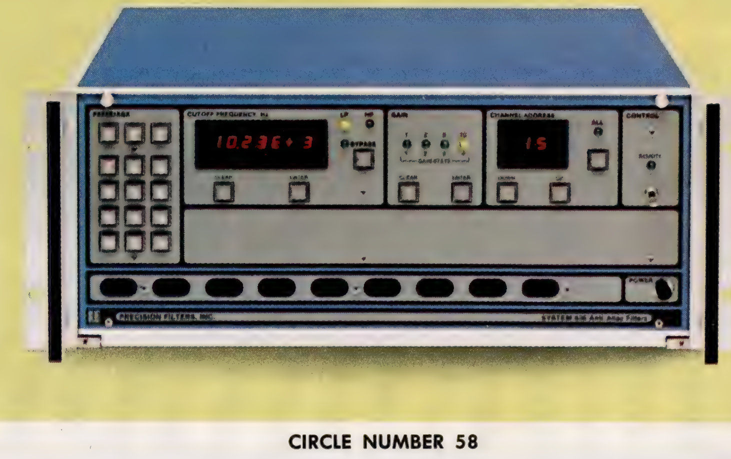
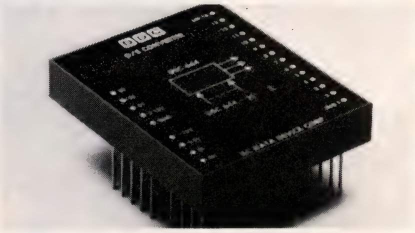


CIRCLE NUMBER 58

14-bit d/s converter assumes low profile

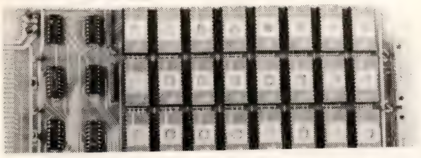


ILC Data Device, 105 Wilbur Pl., Bohemia, NY 11716. (516) 567-5600. From $440.

A 14-bit, 400-Hz d/s converter, DSC-644, stands only 0.52 in. off a board. The device, a pin-for-pin replacement for the industry-standard EDSC-H and L, meets or exceeds the requirements of MIL-STD-202E for severe military, industrial and commercial applications. The low profile results from a new design using fewer parts for improved reliability. Features include internal transformer isolation, low power consumption and a short-circuit proof, current-limiting output stage. Accuracy is ±4 minutes. The device accepts a digital input angle (either TTL or CMOS) and a reference excitation for conversion to a synchro or resolver output capable of driving control transformers, control differential transmitters and angle indicators. Two versions are available for operation from 0 to 70 C or −55 to +85 C.

CIRCLE NO. 322

ROM loader operates with 990 processors

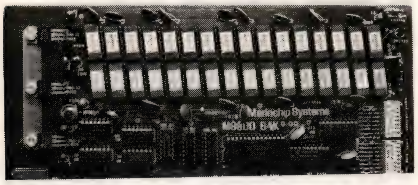


National Data, One National Data Plaza, Corporate Square, Atlanta, GA 30329. (404) 329-8513. $350; stock to 2 wks.

A ROM loader card, RL990-1, allows rapid reloading of remote 990 processors. The board is compatible with 990/4, 990/5, 990/10 and 990/12 processors. The unit is capable of loading a 16-kword program in less than 1 s. Using a TMS 2516 memory, program storage is 64 kbytes; TMS 2532, 128 kbytes. Data transfer rate is approximately 400 kbytes/s. RL990-1 occupies a half a card slot on a CRU bus. Power requirement is 5-V at 400 mA plus 100 mA for each TMS 2516 or plus 160 mA for each TMS 2532.

CIRCLE NO. 323

RAM board doubles speed of 9900 μP-based CPU

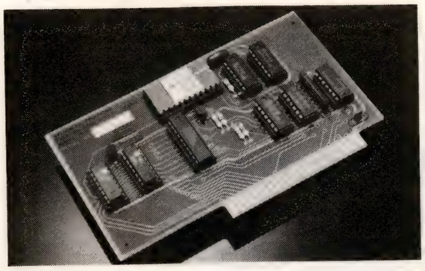


Marinchip Systems, 16 Saint Jude Rd., Mill Valley, CA 94941. (415) 383-1545. $1050; stock to 4 wks.

A 64-kbyte RAM board, M990064K, doubles the effective speed of its companion 9900 microprocessor-based CPU board. The memory is organized as 32 kwords of 16 bits. Memory requests from the M9900 CPU are serviced more quickly by the M990064K board than by regular 8-bit wide, S-100 memories. The memory runs at the full 3.3-MHz speed of the CPU. The memory board contains a 16-bit I/O port which controls bank selection on the board. Each bit in the I/O port controls whether a 4-k page of the board is enabled. Thus, memory management software can allocate pages of the memory in 4-k blocks. The M990064K uses 4116 dynamic RAMs, with a transparent refresh controller. The board can be mixed with conventional 8-bit memory cards in one system.

CIRCLE NO. 324

Processor board boosts Apple math power/speed



California Computer Systems, 250 Caribbean Dr., Sunnyvale, CA 94086. (408) 734-5811.

An arithmetic processor board, Model 7811B increases the number of math functions, as well as execution speed, for Applesoft II users. The increased speed allows more sophisticated, high-resolution graphics on the Apple II computer. Using the AMD9511 APU, the board provides high performance on fixed and floating point arithmetic operations and on floating point trigonometric operations. Model 7811B plugs into an expansion slot on the Apple II. CCSoft interpreter is loaded from a diskette provided with the board. Model 7811B maintains a precision of 6.5 or more, significant digits and offers a range of approximately $10^{\pm 20}$.

CIRCLE NO. 325

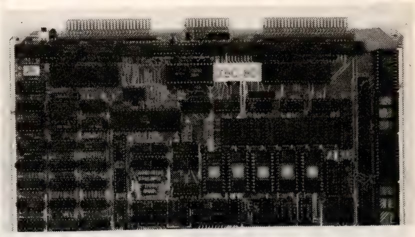
Multibus controller runs four 8-in. floppy drives

Micromation, 1620 Montgomery St., San Francisco, CA 94111. (415) 398-0289.

An Intel Multibus-compatible controller, MM-SBC-80, directs up to four Shugart 800/850 type 8-in. floppy disk drives in both single and double-density mode. A user can read and write from a single-density diskette on one drive to a double-density diskette on another drive, or vice versa. The controller automatically determines the density of an inserted diskette. With four, double-density drives, a user can access up to 2 Mbytes of on-line data storage. Features include a DMA channel for fast block transfer, on-board sector buffer, write precompensation circuitry and CRC error checking. The controller is also available as part of a complete floppy disk subsystem, the MM-SBC-80 Megabox. The system includes two Shugart drives, the controller, a power supply, a rack-mount or desktop enclosure and all connections.

CIRCLE NO. 326

Z-80 based computer board joins with strong software

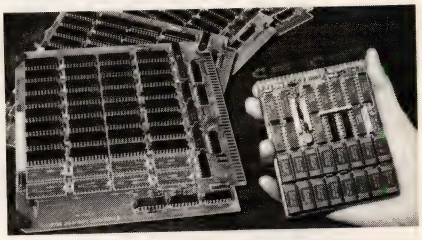


Matrox Electronic Systems, 5800 Andover Ave., Montreal, QUE H4T 1H4. (514) 735-1182.

A Z-80A based single-board computer, ZBC-80, gets extensive software support from Digital Research's CP/M2.0 disk operating system and a variety of high-level language utilities, including Fortran, Pascal, Cobol and Basic. The card contains a dedicated arithmetic processor, a 16-level programmable interrupt controller, 16 to 64 Kbytes of RAM and sockets for up to 40-k of ROM or PROM. Also included are bootstrap-on-reset circuitry, six programmable parallel I/O ports, six programmable timer/counters and a serial communications controller. Arithmetic processing capabilities are enhanced by an optional math chip, Am9511 or Am9512. On-card bus arbitration logic increases system throughput by allowing up to three masters on the system bus on a shared basis. With external logic, up to 16 masters can be used in a parallel priority fashion.

CIRCLE NO. 327

Plug-in boards boost IBM 303X memory

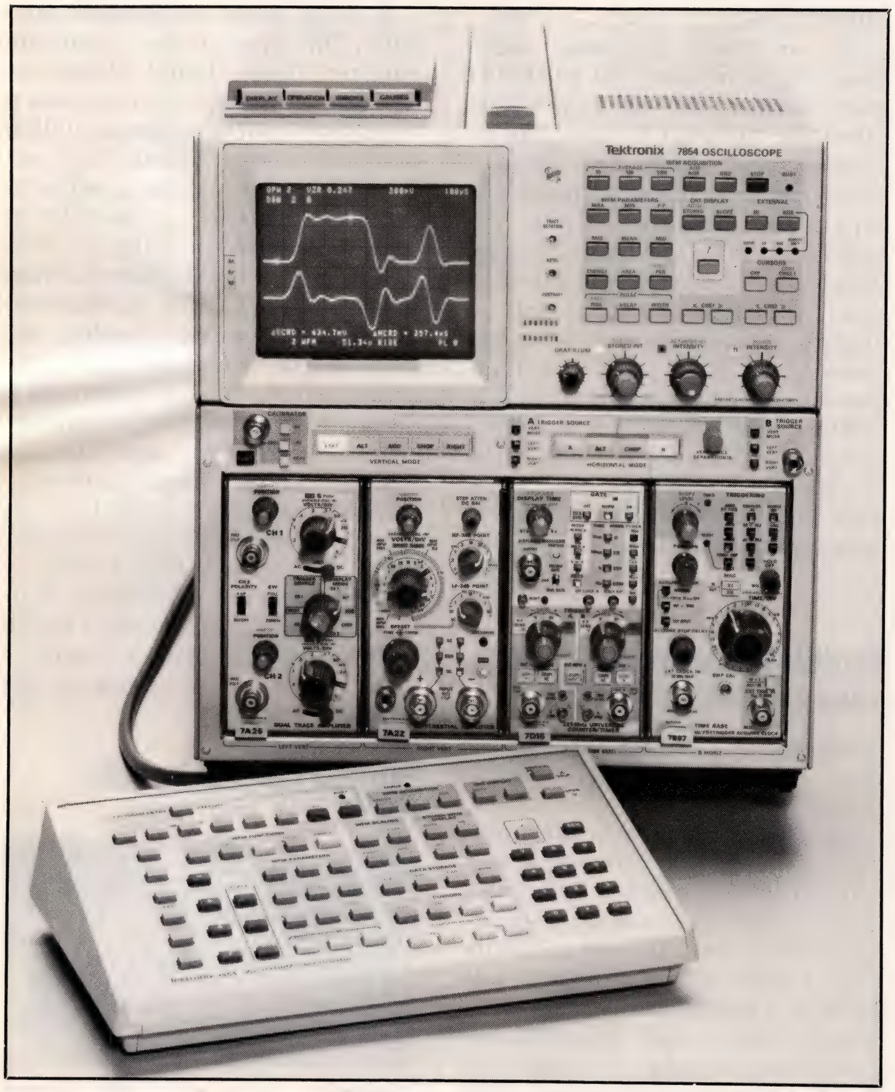


Cambridge Memories, 360 Second Ave., Waltham, MA 02154. (617) 890-6000. 4 to 8 wks.

STOR/3000, an add-in memory board based on 64-k RAMs, plugs directly into the storage backplanes of IBM 303X systems. The board increases memory density yet appears completely transparent to all IBM hardware and software. Use of standard IBM MST-compatible logic eliminates the need for complex 'translation" circuitry and aids interface to the IBM system.

CIRCLE NO. 328

Analog scope gets smart—and gets on the GPIB, too



Tektronix Inc., P.O. Box 500, Beaverton, OR 97077. (503) 644-0161. P&A: $10,500; June.

One look at the keyboard attached to the umbilical cable of the Tektronix 7854 suggests that this is no ordinary oscilloscope; the instrument's front panel confirms that impression. Along with all the controls for conventional analog performance, the 7854 possesses special controls for waveform processing. Its innovative capabilities include:

- Digital storage of repetitive waveforms to 400 MHz
- GPIB for systems applications—a first for real-time scopes
- Calculation of waveform parameters with a single keystroke
- User programming
- Signal averaging to cut noise
- Storage of single-shot events.

As a conventional oscilloscope, the 7854 offers a 400-MHz bandwidth, 10-mV/div sensitivity and calibrated sweeps to 500 ps. The unit will accept any of more than 30 7000 series plug-ins. However, the unit really stands out in its digital mode.

With optional memory, the 7854 stores up to 40 digitized waveforms that can be recalled at will for comparisons. Common measurements are preprogrammed, so just a touch of a button on the calculator keyboard sets the 7854 to calculating rise and fall times and pulse widths and comparing complex waveforms.

The unit recovers signals buried in noise by averaging, which also increases resolution—differences as small as 0.01 divisions can be recorded. Users can choose 128, 256, 512 or 1024 horizontal points per waveform.

Users can also tailor their own programs with the keyboard—and the 7854 will calculate and display the answers, even when the user is absent. Without supervision, the unit monitors signals, automates and organizes a long series of measurements, compares expected results with actual results and flags any measurements that exceed specifications.

If additional processing or more storage space for data is desirable or if a measurement system must include several instruments, the standard (GPIB) interface bus comes into play. Over the bus, all waveform data and results can be sent out from the 7854, and keystroke instructions or CRT text can be sent in.

Tektronix offers a signal processing system, the WP 1310, consisting of the oscilloscope and the company's 4052 graphic computing system, a desktop computer that provides high-resolution graphics, extended data-communications capabilities and extended Basic. Signal-processing ROM-packs tailor the WP 1310 for waveform processing. The WP 1310 signal-processing system, a June arrival, lists for $26,350.

CIRCLE NO. 304

Stan Runyon
Executive Editor

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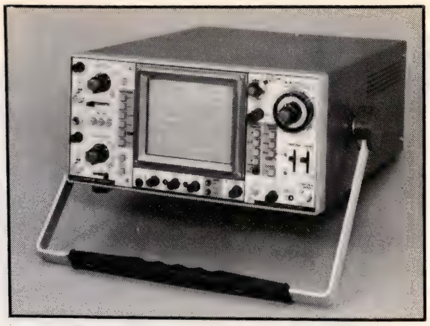
50-MHz portable oscilloscope gives 'brilliant' high-cost performance

Kikusui International Corp., 17121 S. Central Ave., Carson, CA 90745. (213) 638-6107. P&A: See text.

A 50-MHz, dual-trace, general-purpose portable oscilloscope, the 5650, provides not only an 8 × 10-cm rectangular CRT with an internally illuminated graticule but also many other features hitherto associated with higher-priced scopes.

Vertical sensitivity is 5 mV/cm to approximately 5 V/cm up to 50 MHz, with a rise time of 7 ns/cm. Display modes are CH-1, CH-2, ALT, CHOP, ADD and X-Y. The chop frequency is approximately 500 kHz. Timing and trigger functions include delayed sweep, delayed alternate sweep, trigger-level lock, hold-off, B-ends-A, triggered delay, and one-touch X-Y operation.



With B-ends-A, brightness is maintained all through fast-sweep operation on low-repetition-rate signals—a capability especially useful for digital applications.

In addition, both vertical and horizontal axes are 1-2-5 sequenced. Input impedance is 1 MΩ at 20 pF.

The 5650, with illuminated graticule, costs $1895; the 5650E, without illuminated graticule, costs $1730. Deliveries are from stock.

CIRCLE NO. 305

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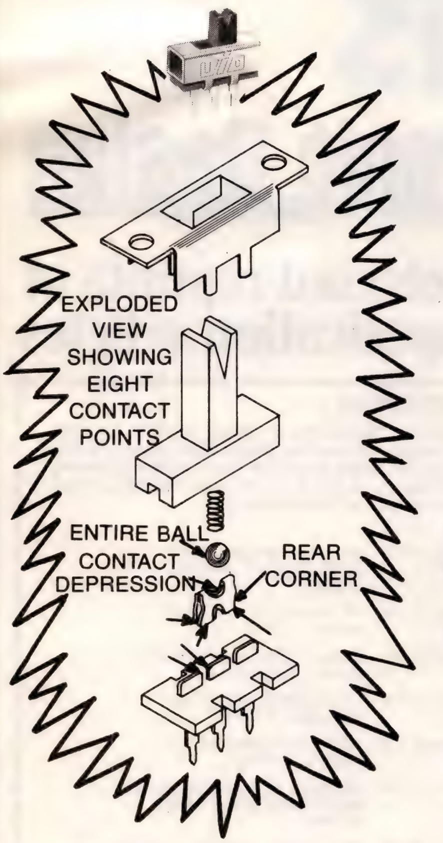
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CIRCLE NUMBER 60

μP control increases DVM capabilities

Datron Instruments, Laguna Hill Business Park, 23011 Moulton Parkway, Laguna Hills, CA 92653. (714) 830-8860. $5000.

Microprocessor control brings a combination of features to the Model 1071 digital voltmeter to simplify calibration and operation. Features of the 7-1/2 digit instrument include complete calibration from the front panel, automatic self-test, error read-out, computing capability and IEEE 488 bus interface. In standard operation, the Model 1071 is a 6-1/2 digit unit with accuracy to ±3 ppm. For greater accuracy and resolution, an "average" key automatically extends readings of 7-1/2 digits and provides a resolution of 10 nV or 0.05 ppm full scale. Plug-in cards expand the basic dc voltmeter to include capabilities for dc current, true rms ac voltage and current, dc-coupled true rms voltage and current, resistance and ratio measurements.

CIRCLE NO. 329

The New Generation of Custom Monolithic Hybrid Converters from DDC.

By using customized monolithic chips, DDC has taken a giant step forward in converter technology. The new product—Monobrid—is much smaller, less complex, more reliable and requires less power than conventional hybrids.

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For more information about DDC's new 8915 Series Monobrid converter, call or write Department B-5, today.

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Note: Monobrid™ is a trademark of ILC Data Device Corporation

CIRCLE NUMBER 61

Why you should "Think Crydom" for power SSRs.

The Inside Story.

Most photo-isolated solid-state power relays of today look alike. But they don't always perform alike. They look alike because the package developed by Crydom has become the industry standard worldwide. That's where the similarity to Crydom Series 1 usually ends. Review these reasons to "Think Crydom." They have made Crydom the largest selling SSRs in the world.

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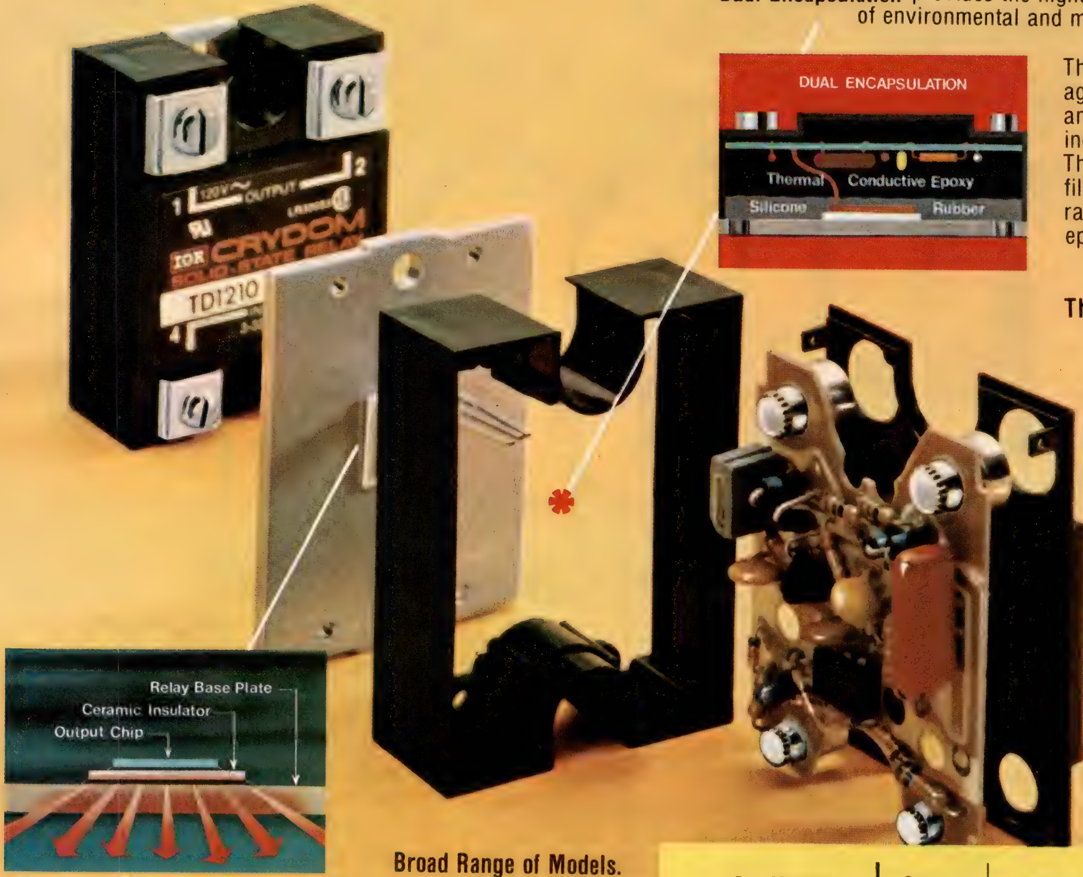

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	TD1225	24-140	25	200
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AC INPUT CONTROL MODELS	TA1205	24-140	5	50
	TA1210	24-140	10	100
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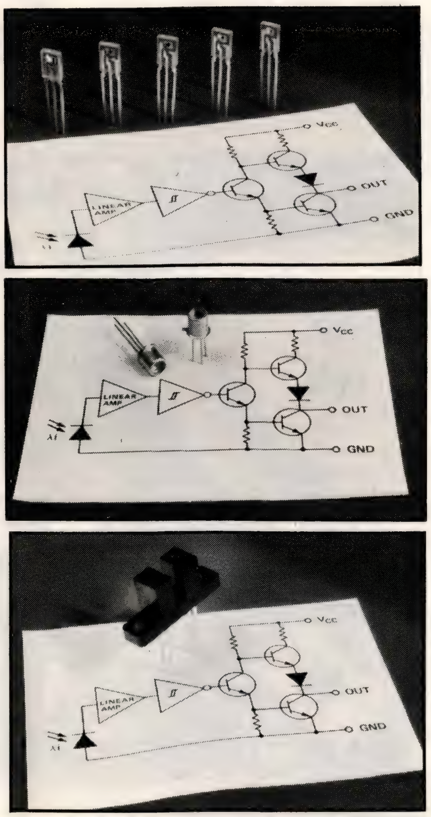
TTL-compatible couplers come as chips, assemblies



Ranging from single photosensor chips to complete optocoupler assemblies, three of the four Photologic configurations are shown. The remaining type is an interrupter similar to the bottom package.

TRW Optron, Inc., 1201 Tappan Circle, Carrollton, TX 75006. Jerry Basham (214) 242-6571. P&A: See text.

A new family of optoelectronic interface couplers, called Photologic by TRW Optron, mates directly to TTL loads, thereby eliminating design problems that occur with conventional sensors having phototransistor outputs. What's more, the devices will be available either as photosensor chips or as complete coupler assemblies with infrared emitting diodes, and will encompass 14 different packaging and logic configurations.

Each Photologic chip is a monolithic integrated circuit consisting of a photodiode, linear amplifier and a Schmitt trigger on a single silicon surface. The chip is encapsulated in a molded plastic package with an integral lens. This allows chips to be coupled to compatible emitting diodes such as TRW Optron's OP140. Thus, users who wish to make their own custom optical-coupler assemblies can purchase photosensor chips and light emitting diodes as separate components.

One such photosensing sensing chip, the OPL550 (top photo), is a buffer with a totem-pole output. Besides providing high immunity to noise on both the input and V_{cc} lines, the chip boasts a typical propagation delay time of just 2 μs, making it about twice as fast as its competition. Rise and fall times are rated at 25 ns typical, and all electrical characteristics are specified over −40 to +70 C. The same electrical specifications are available in three companion chips: the OPL550C, a buffer with open-collector output; the OPL551, a totem-pole inverter; and the OPL551-OC, an open-collector inverter.

Other devices available include the OPL800W (middle photo), a totem-pole buffer and emitting diode housed in a three-leaded can with a lens top. In addition, the OPB913S10 (bottom photo) and OPB947 are both totem-pole buffers with integral light emitting diodes, housed in two different interrupter-type packages.

Presently available beam interrupter assemblies normally require amplification and/or signal shaping at the output to present usable signals to the logic. A one-stage transistor amplifier and a single Schmitt trigger can perform the signal conditioning function quite satisfactorily. The clock frequency, however, is limited to about 5 kHz without adding extensive detection circuitry. If the output transistor in a beam interrupter assembly is replaced with a photologic device, the clock frequency can be increased to 200 kHz. This allows systems to measure shaft speeds over 600 rpm and to handle information rates of 500 bits/revolution. What's more, converting from the traditional output transistor to Photologic represents only a slight increase in system cost.

Chips are available from stock and cost $2.50 each in quantities of 1000.

CIRCLE NO. 306

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Still the only programmable Vector Voltmeter available is the PRD 2020. It has 50-ohm coaxial inputs (no probes); and its control functions can be programmed through a single rear-panel connector by standard TTL logic levels. Planning to automate your RF and microwave testing? Learn more about the cost-effective P2020 Vector Voltmeter... send for latest application notes on our Vector Voltmeter series. Write:
Harris Corporation,
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1200 Prospect Avenue,
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CIRCLE NUMBER 64

HEXFET line gains chips and medium-power devices

International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, CA 90245. (213) 772-2000. P & A: See text.

Rounding out its line of HEXFET power MOS devices, International Rectifier introduces a line of medium-power devices and unpackaged chips.

Intended for motor controls and switching power supplies, the new series of medium-power devices are rated 100 to 400 V, 2.5 to 6 A, with on-resistances ranging from 0.3 to 1.8 Ω.

The unpackaged chips are for military and industrial hybrid circuits and custom applications that require other packaging options than the TO-3 and TO-220 cases. The clips handle from 60 to 400 V, with on-resistances from 0.14 to 1.5 Ω.

The medium-power devices come in TO-3 or TO-220 packaging. Devices in the TO-3 package include the IRF120, rated at 100 V, 6 A and 0.3 Ω on-resistance; the IRF220, rated at 200 V, 4 A and 0.8 Ω; and the IRF320, rated at 400 V, 3 A and 1.8 Ω.

Devices in the TO-220 package include the IRF520 for 100 V, 5 A and 0.3 Ω; the IRF620 for 200 V, 3.5 A and 0.8 Ω; and IRF720 for 400 V, 2.5 A and 1.8 Ω on-resistance. In small quantities the TO-3 packages cost from $10.80 to $16.80, and the TO-220 packages cost from $9 to $15. Samples are available from stock.

The unpackaged HEXFET devices come with three different ratings and in three sizes: The smallest is the HEX-2 (90 × 138 mils), which is rated for a 100-V breakdown, max, and an on-resistance of 0.14 Ω typical (0.25 Ω max) with a current drain of 1 A. The medium-sized chip, HEX-3, is 180 × 114 mils. It is rated for 200 V and a maximum on-resistance of 0.6 Ω with 1 A. The largest chip, HEX-5, is 250 × 250 mils. It is rated for a breakdown voltage of 400 V and a typical on-resistance of 0.8Ω (1.5 max).

All HEXFET devices provide the same planar geometry with 500,000 source cells per square inch of silicon surface.

Price and delivery for the unpackaged chips will depend on the chip size and quantity.

Transistors	**CIRCLE NO. 307**
Unpackaged chips	**CIRCLE NO. 308**

Test in accordance to FCC, CISPR, VDE, & MIL. standards

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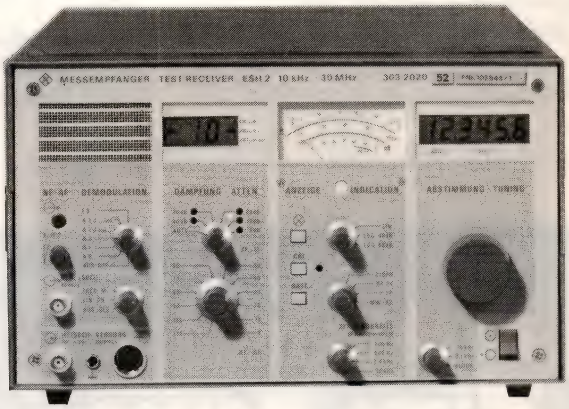

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CIRCLE NUMBER 65

VMOS power FETs shoulder 400-V loads and switch fast

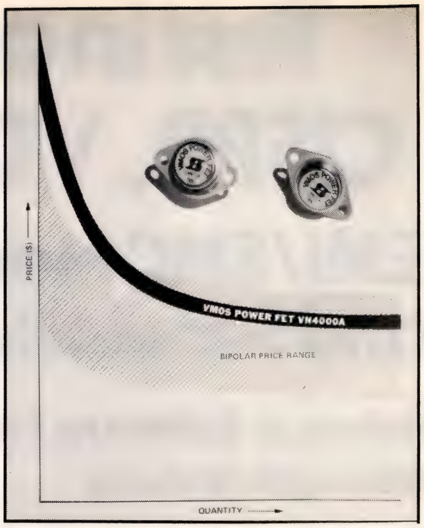
Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. Gary Hess (408) 988-8000. P & A: See text.

High-voltage VMOS power FETs from Siliconix handle 400-V loads and 8 A continuously, with less than 1.5 Ω of on-resistance, and no more than 500 μA of dc leakage current in the off state.

As the second generation of Siliconix power MOSFET devices, the VN4000A and VN4001A incorporate the V-groove structure of n-channel enhancement-mode devices into a system of parallel cells. Each cell handles progressively higher voltages with progressively lower on-resistance and lower voltage drops in the on-state.

Like the best power MOS devices, however, the VN4000 series is capable of exceptionally fast switching. Both models will turn on (or turn off) within 100 ns. At these switching speeds and with no secondary breakdown, the power-MOS devices are more energy-efficient than bipolars in switching-power-supply applications, according to Siliconix. Efficiency can reach 95% in many applications, especially as the frequency increases. The fast response time guarantees useful operation through 200 kHz, though the devices have been successfully tested up to 150 MHz.

Currently available in TO-3 cans, the VN4000A and VN4001A are $9.00 each in small quantities. Available from stock at Siliconix distributors. TO-220 packaging will be available later in the year.



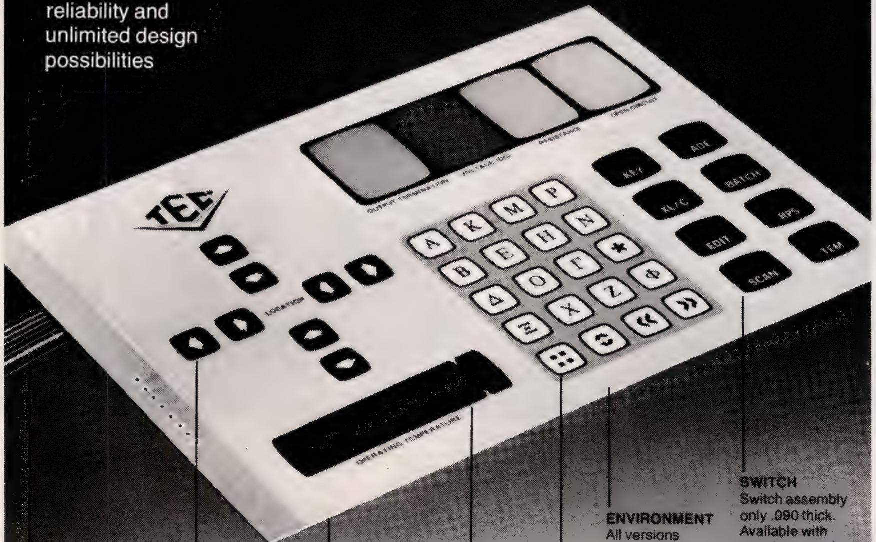
CIRCLE NO. 309

Step motors operate at up to 10,000 steps/s

TRW Globe Motors, 2375 Stanley Ave., Dayton, OH 45404. (513) 228-3171.

A line of 1.8° step motors operates at speeds to 10,000 steps/s. The permanent-magnet units come in two frame sizes: 2.248 and 3.386 in. diameter. Lengths range from 1.5 to 5 in. Step accuracy is ±3% non-cumulative. The motors can be driven by unipolar R/L, bipolar R/L or bipolar chopper drivers. Operating range is −40 to +65 C with continuous duty temperature at 65 C. Winding insulation is Class B.

CIRCLE NO. 330



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CIRCLE NUMBER 66

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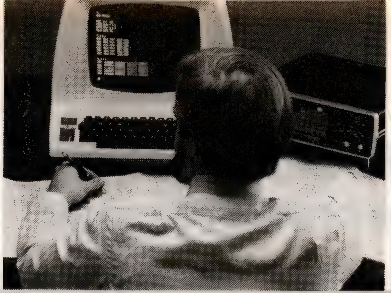
Or with a scope.



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PARATRONICS

ADDITIONAL INFORMATION CIRCLE NUMBER 67 **FOR A DEMONSTRATION CIRCLE NUMBER 77**

Low-cost, single-chip sensors more than triple pressure range

National Semiconductor, 2900 Semiconductor Drive, Santa Clara, CA 95051. Ray Pitts (408) 737-5854. P & A: See text.

Low-cost monolithic pressure sensors from National Semiconductor extend the range of single-chip transducers from 30 psi all the way to 100 psi. Intended as alternatives to hybrid pressure sensors with on-board signal conditioning, the LX0520 and LX0620 provide excellent sensitivity (0.2 to 0.8 mV/psi), a small temperature coefficient smaller than 0.02 mV/°C and on-chip temperature compensation over an operating range of 0 to 85 C.

Easy to use, the sensors will function on a single 7.5-V supply. They come in either TO-5 or popular ceramic packaging. In the TO-5 package, the LXO520A is an absolute pressure sensor. In ceramic packages, the LXO620GB registers gauge pressure, and the LXO620D registers differential pressure.

In small lots, the LXO520A costs $30, the LXO620GB and LXO620D, $36. Delivery is stock to six weeks.

CIRCLE NO. 310

Double time, double value.

Now MACROLINK offers Perkin-Elmer/Interdata users both synchronous and asynchronous communication line adapters — with twice as many lines per board at half the price every time!

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*Both PADLA and QALTA replace expensive PALM/PALS or multiplexer boards; PSDLA replaces QSA/SSA and their LCM's. OEM discounts available.

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1740-E South Anaheim Blvd.
Anaheim, CA 92805
(714) 535-4500

CIRCLE NUMBER 68

Mica capacitors keep working at 300 C

KD Components, 3016 Orange St., Santa Ana, CA 92707. (714) 545-7108.

Leads, brazed to the element, permit high-temperature operation of a line of ruby mica capacitors. High insulation resistance and moisture protection are assured by encapsulated packages. The capacitors are available in ranges from 1 to 250,000 pF and 50 to 2000 V dc. Tolerances are as low as ±1%. Overall temperature range is −55 to +300 C.

CIRCLE NO. 331

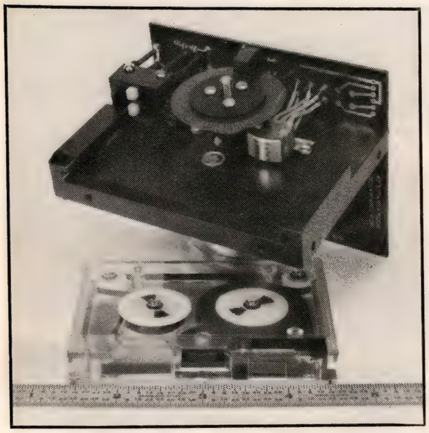
Submini dc gearmotor makes mounting easy

Portescap U.S., 31 Fairfield Pl., West Caldwell, NJ 07006. (201) 227-0322.

A subminature dc gearmotor, Model 915, comes in a rectangular package to simplify mounting choices. The unit measures only 9 × 15 mm with length ranging from 22.4 to 35.5 mm, depending on the model. Motor resistance is 8.6 Ω; motor constant, 0.00215 Nm/A (0.3 oz-in./A). Maximum recommended output torque is 200 g-cm (3 oz-in.); maximum input speed, 800 rpm. Gear stages range from one to six with reduction ratios from 3.66 to 1 and 2400 to 1.

CIRCLE NO. 332

Small drive for DC100 cartridges features unjammable retainer



Moya Corp., 6311 De Soto Ave., Bldg. H, Woodland Hills, CA 91367. (213) 533-5993.

Lightweight (at 11 oz.) and compact (2⅝ × 3⅝ × 3 in.), a series of magnetic tape drives boasts a patented cartridge retainer that cannot jam. The Macro-Drive/OEM series, which marks the entry of Moya Corp. into the magnetic-tape transport market, accepts the DC100A Data Cartridge or equivalent.

The drives contain a motor, tachometer disk and sensor, read/write head, cartridge-in-place and file-protect sensors and a hole-in-tape sensor. A minimum electronics model also has a switching power amplifier for motor drive, comparators for tach and hole-in-tape sensors, a write amplifier and read preamp.

The patented cartridge retainer consists of two rotatable, circular, flat-walled disks that are held to proper bias by two blade springs. The springs are attached to the main plate on both sides of the tape receptacle. No locking mechanism is used; the drive itself properly locates and holds the cartridge in place.

Without the minimum electronics, the drives cost $260 each; delivery is 30 days.

CIRCLE NO. 321

Flexible disk system works with IBM/DEC formats

Data Systems Design, 3130 Coronado Dr., Santa Clara, CA 95051. (408) 249-9353. $4495; 4 to 6 wks.

A flexible disk memory system, DSD 480, doubles system capacity for DEC LSI-11 and PDP-11 users. In addition, the unit allows convenient data and program transfer between DEC and IBM computers. The memory system reads and writes on both sides of industry-standard 8-in. diskettes for a formatted capacity of 1 Mbyte per diskette or 2 Mbytes of on-line storage. Features include built-in hardware bootstrap, off-line diskette formatting and "Hyperdiagnostics," a library of built-in user-selectable routines to perform self-tests independently from a computer. The DSD 480 is packaged in a low-profile 5-1/4 in. chassis for rack mounting or tabletop operation.

CIRCLE NO. 333

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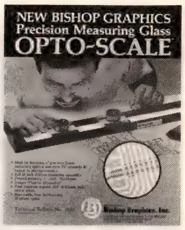

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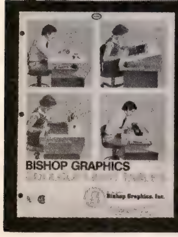

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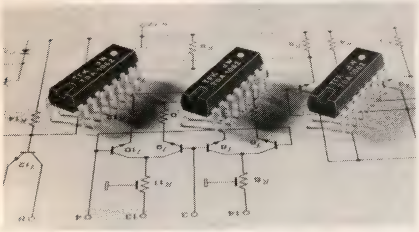
CIRCLE READER SERVICE NO. 70
For OPTO-SCALE Information

CIRCLE READER SERVICE NO. 80
For LIGHT TABLE Information

Single-chip front-end covers entire VHF range

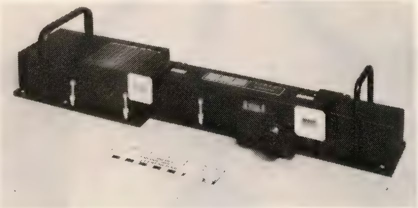


AEG-Telefunken, Rt. 22, Orr Dr., Somerville, NJ 08876. (201) 722-9800. $2.50 (1000 qty).

A monolithic IC, TDA1062, comprises a complete VHF front end. The circuit operates from 30 to 250 MHz and includes an rf amplifier, an oscillator, a double-balanced mixer, an agc preamplifier and voltage regulating circuitry. The chip finds use in medium and high-quality communications receivers, FM front-ends, high-frequency mixers, phase detectors and modulators. Model TDA1062S includes an on-chip oscillator buffer for use in synthesized VHF tuners where higher oscillator output levels are necessary.

CIRCLE NO. 334

TWT generates 250 W in Ku-band earth terminal

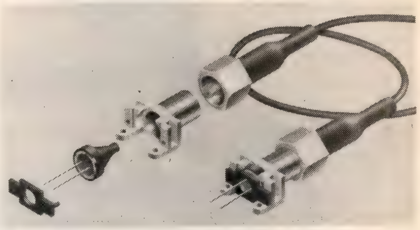


Hughes Electron Dynamics, 3100 W. Lomita Blvd., Torrance, CA 90509. (213) 534-2121.

A 250-W traveling-wave tube (TWT), Model 881H, provides continuous power in the 14 to 14.5-GHz range. The metal-ceramic tube has a modulating anode for fast turn-on and turn-off of beam current during normal operating sequencing and under fault conditions. The tube body is conduction-cooled through its baseplate support. An integral collector thermal switch allows tube turn-off under excessive temperature conditions. Bandwidth is 500 MHz minimum; gain at rated power output, typically 45 dB; nominal efficiency, 25%. Model 881H measures 21.6 in. long and is 5.2 in. at its widest point. Weight is 11 lb.

CIRCLE NO. 335

Fiber optics pair boosts speed in comm systems



Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. Harry Koski (602) 244-4305. $30 (detector); $35 (emitter) (100 qty); stock.

A p-i-n photodiode detector and an infrared LED emitter give improved speed performance for analog or digital fiber optics communication. The detector, MFOD104F, has a typical response time of only 2 ns at 20 V and 6 ns at 5 V. It works in analog systems requiring a bandwidth of up to 100 MHz or in digital systems with a speed requirement of up to 200 Mbaud. In datacomm links operating at 5 V, the detector is useable up to 110 Mbaud. The emitter, MFOE103F, operates at up to 20 Mbaud. Both devices are packaged in plastic cases and fit directly into AMP's Optimate connectors.

CIRCLE NO. 336

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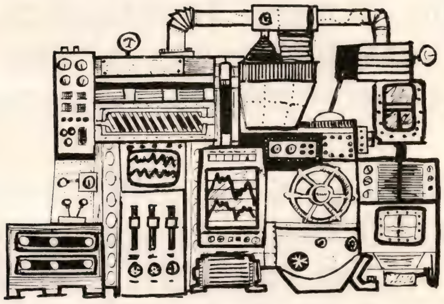

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The Bipolar Interface Specialist

CIRCLE NUMBER 72

Phenolic bounces back from impacts

General Electric Plastics, One Plastics Ave., Pittsfield, MA 01201. (413) 494-1110.

GENAL MX582P, a modified phenolic molding compound, combines high heat deflection temperatures (over 550 F) with impact strength. Post-baking for 5 h at 350 F permits continuous exposure to 450 F for 100 h with no loss of flexural strength. The material provides impact resistance without the penalty of increasing specific gravity. Elimination of glass-reinforcement helps keep costs lower. MX582QP is supplied in pelletized form and is virtually dust-free. It pours easily in conventional thermoset injection molding systems.

CIRCLE NO. 337

Polycrystalline material performs at high temps

GTE Sylvania, P.O. Box 220, Exeter, NH 03833. (603) 772-4331.

A polycrystalline material, called anistropic pyrolytic boron nitride (PBN), exhibits good heat conductivity, making it suitable for crucibles and components used for evaporation, crystal growing, zone refining and microwave tube insulation. Heat travels faster along the surface of PBN than straight through. Conductivity along an outer surface is about the same as that of cast iron. Heat passing through walls travels at about the same rate as through porcelain, providing uniform heat without hot spots. At higher temperatures and pressures, PBN becomes stronger. PBN is very inert and extremely pure, containing less than 10 ppm of metallic imputities. The material is produced by chemical vapor deposition in a reaction chamber.

CIRCLE NO. 338

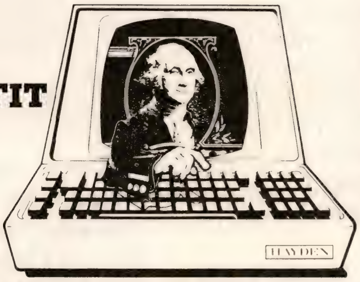
One-part epoxy meets high-temperature needs

Epoxy Technology, 14 Fortune Dr., Billerica, MA 01821. (617) 667-3805. 1 to 2 wks.

Epo-Tek 390, a single-component solvent-based epoxy, bonds or coats parts operating at temperatures as high as 537 C. Designed primarily for thin or thick-film bonding or coating, the epoxy adheres to a number of surfaces, including metals, glass, ceramic and quartz. Other uses including bonding of fiber optics and as a high-temperature coating. Cure schedule is 30 minutes at room temperature then 1 h at 200 C. Shelf life, at room temperature, is one year. Epo-Tek 390 comes in 1/2 oz, 1 oz, 2 oz an 6 oz quantities.

CIRCLE NO. 339

The fun's already there... this guide puts the *profit* into personal computers!



HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: Professional, Business, and Home Applications
by T. G. Lewis

For every small business owner and professional, this guide describes the many business uses of personal computers and gives actual BASIC language programs for such diverse uses as: accounting, handling payrolls, managing inventory, and sorting mailing lists. It is written in an entertaining style with many anecdotes and tales of success.
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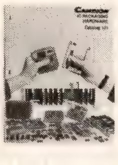

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CIRCLE NUMBER 73

Computer-based system reduces drafting time

Nicolet CAD, 2530 San Pablo St., Berkeley, CA 94702. Mike Smith (415) 848-6600. $73,200.

A computer-aided drafting system with full-color display, System 80, increases productivity and reduces drafting time on PC-board layouts, schematic diagrams, hybrid circuits and mechanical drawings. The system uses a 32-bit display processor for instantaneous pan, zoom, erase and drag of complex graphic objects on a high-resolution screen. A moveable keyboard permits fast creation of complicated work and revisions at the touch of a button. A user can select from 20 different colors and 512 shades for easy distinction of layers, pads, DIPs, lettering, cursor position or computer prompting. The system includes a storage tube terminal with its own processor, a Basic interpretor and an integral cartridge tape drive for safe, compact storage of drawings and designs. Also included is a Zeta 3653SX pen plotter to produce camera-ready artwork.

CIRCLE NO. 340

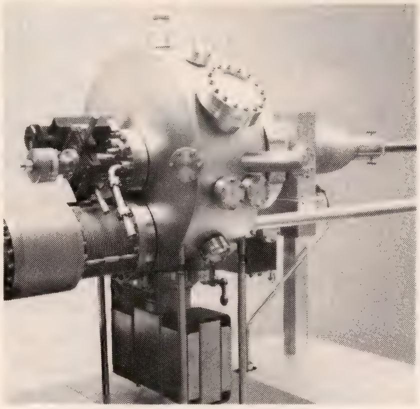
Simple tool pulls nails from semi shipping tubes

Meritex Plastic, P.O. Box 5314, Arlington, TX 76011. (817) 265-1556. Under $1.00.

A small, nylon hand tool, Nail Saver, pulls and re-inserts plastic nails used as end stops in plastic semiconductor shipping tubes. The tool helps prevent sore fingers and broken fingernails.

CIRCLE NO. 341

Epitaxial growth system grows 2-in. semis



Varian Vacuum Div., 611 Hansen Way, Palo Alto, CA 94303. Dr. Tom Cooper (415) 493-4000. From $200,000.

A molecular-beam epitaxial growth system, MBE-360/GEN II, grows semiconductor wafers as large as 2-in. with high film-thickness uniformity. Intended for III-V, II-VI and IV-VI compound semiconductors, the system provides greater throughput than its predecessor, the research-oriented MBE-360. Molecular-beam epitaxy permits the growth of a wide variety of materials used in microwave and optoelectronic devices. Epitaxial growth takes place in an ultra-high vacuum environment through the chemical reaction of multiple molecular beams of differing flux densities with a heated mono-crystal substrate. A load-load device on the new system permits rapid introduction of a sample into the growth chamber without exposing the chamber to atmospheric pressure. A preparation/analysis chamber allows samples to be cleaned and materials to be evaporated onto a specimen to form Schottky barriers or ohmic contacts for surface analysis studies.

CIRCLE NO. 342

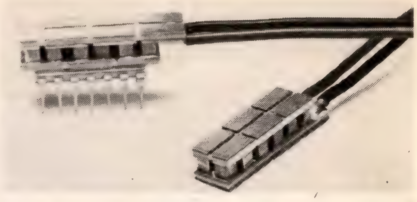
Wafer dicing blades fit 3/4 in. spindles

Micro Automation, 275 Santa Ana Ct., Sunnyvale, CA 94086. (408) 737-1880. $99.

Nickel-bonded wafer dicing blades fit standard 3/4 in. saw spindles. The long-life blades produce repeatable kerfs with low chipping in silicon wafers. Blade thicknesses range from 0.02 to 0.084 mm; edge exposures, 0.25 to 0.89 mm. The blades are made in Belgium and are available at the introductory price of $99 until May 15.

CIRCLE NO. 343

Electric cooler pumps heat from DIPs



Cambion Thermionic, 445 Concord Ave., Cambridge, MA 02238. (617) 491-5400. $4.90 (OEM qty).

Sandwiched between a DIP and a heat sink, the Model 801-1029-01-00-00 thermoelectric module pumps up to 3.5 W of heat. Use of the device permits more circuitry in a DIP or allows operation of a device in a hot environment. Since a reversal of current direction allows the module to heat as well as cool, the unit can be used to regulate DIP temperature to any preset value to minimize thermal drift. The cooler is available for 8, 14, 16 and 18-lead DIPs.

CIRCLE NO. 344

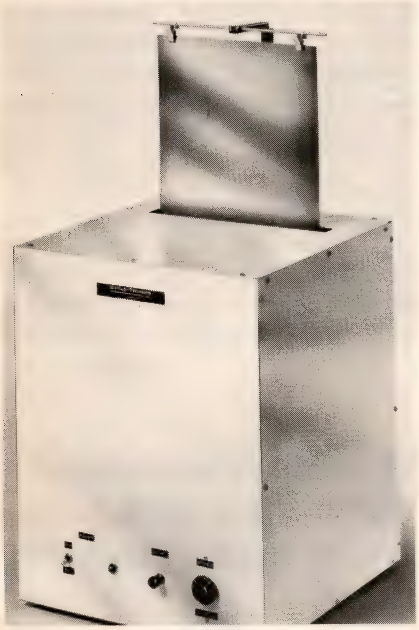
Board holder lends a hand during soldering/wrapping

Studio 3, P.O. Box 1184, Kailua, HI 96734.(808) 261-6686. $9.95 to $14.95.

A spring-action PC board holder, The 3rd Hand, requires no screws or arms to hold boards securely for soldering or wire-wrapping. Boards are safely gripped when inserted into a PVC gasket. Clamped to the edge of a workbench, the holder keeps boards at a convenient angle for parts placement. Flipped forward, the underside of a board is exposed for soldering. The open-end design of the 3rd Hand means no adjustment is necessary to accommodate various size boards. Three models are offered, from a 4-in. holder to a 7-5/16-in. version for industrial boards and single-board computers. An optional extension clamp holds boards farther back on a bench for more comfortable work.

CIRCLE NO. 345

Dip coater automates PC-board production



Cyclo-Tronics, 3858 N. Cicero Ave., Chicago, IL 60641. (312) 282-6141. $710.

A PC-board dip coater, Model 206, automates coating of copper-clad boards, or other flat sheet materials, with photosensitive resists. The unit, intended for prototyping or low production use, automatically lowers boards into its stainless steel tank and withdraws them at a preset rate. Model 206 handles single or double-sided boards of up to 11 × 14 in. The unit itself measures 16 × 16 × 20 in. and is an addition to a line of PC-board processing and etching systems.

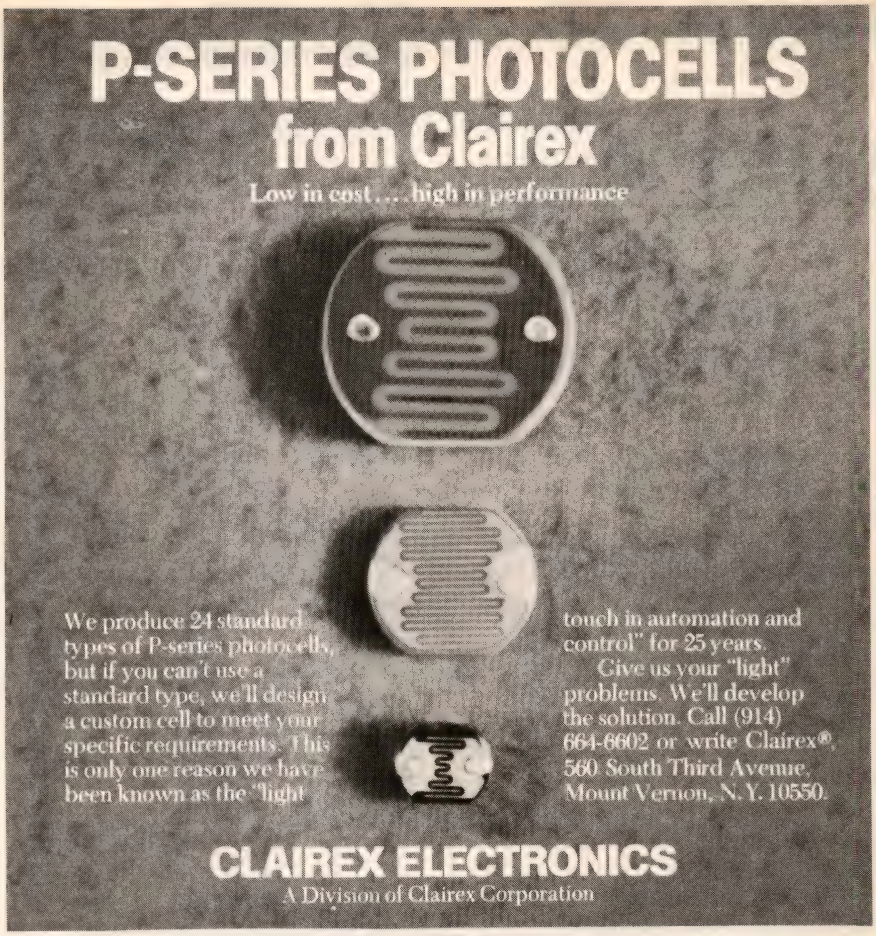
CIRCLE NO. 346

Burn-in socket isolates devices from system

Wells Electronics, 1701 S. Main St., South Bend, IN 46613. (219) 287-5941. 6 to 8 wks.

A DIP burn-in and test socket, Series 6035, electrically isolates any device mounted in it from all other devices in a burn-in tray or system. The sockets have gold-plated berrylium-copper contacts that accommodate vertically-mounted isolation resistors. The contact design saves board space and allows flexing of the soldered assembly under extreme temperature cycling from ambient to 200 C. The sockets can be used in static or dynamic burn-in applications. Failure of any device-under-test will not affect the signals to other parts of the burn-in tray. Bodies are molded of heat-resistant Ryton.

CIRCLE NO. 347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CIRCLE NUMBER 74

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CIRCLE NUMBER 75

Tuneful chip makes music in 128 notes and 28 tempos

Panasonic, One Panasonic Way, Secaucus, NJ 07094. Bill Bottari (201) 348-7276.

A CMOS chip, MN6221, draws on a memory of 128 notes and 28 tempos to create melodies for clocks, toys, electronic music boxes and telephones. The device is mask-programmed to contain up to seven different tunes. A complete music-producing circuit, built around the MN6221, requires only a few external resistors, capacitors and a speaker. The circuit spans four octaves and is capable of two chords. Since it is mask-programmed, an unlimited variety of melodies can be chosen. Within the chip are melody storage ROM, dual programmable counters for tone generation, a tempo generator, and oscillator and note time, input control and audio output circuits. Delivery is 12 weeks after prototype approval.

CIRCLE NO. 348

High-density CMOS RAMs save memory power

OKI Semiconductor, 1333 Lawrence Expy., Santa Clara, CA 95051. (408) 984-4840. $20.70 (200 ns); $19.20 (300 ns) (100 qty).

Two high-density, 4-k, CMOS RAMs, MSM5104 and MSM5115, reduce operating power needs to less than 33 mW/MHz. Standby power is so low, 200 μW, that designers can plan batteries as a backup power source. MSM5104 is organized as 4096 × 1-bit; MSM5115, 1024 × 4-bits. Two versions of each chip allow a choice of 200 or 300-ns time. Inputs and outputs are TTL and CMOS compatible. MSM5104 is pin-compatible with the Mostek 4104 and is interchangeable with the Harris 6504. The MSM5115 memory can replace the Intel 2114 and is interchangeable with the Harris 6514.

CIRCLE NO. 349

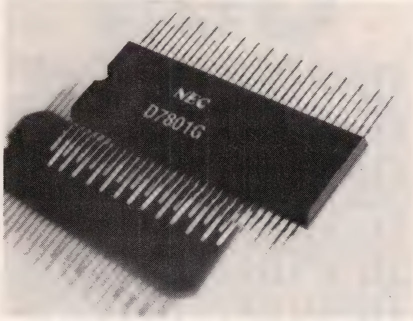
256-bit NMOS memory retains data for one year

Panasonic, One Panasonic Way, Secaucus, NJ 07094. Bill Bottari (201) 348-7276. Stock to 8 wks.

A 256-bit, electrically-alterable NMOS memory, MN1208, retains data for one year without the aid of a power supply. The fully decoded, nonvolatile memory is suited as a peripheral device for 4-bit microcomputers. Mode, address and data inputs are obtained through four common input terminals and are latched. Besides the main 16-bit × 16 memory, the chip has a separate one-word, 12-bit memory. The device comes in an 18-pin plastic DIP and requires two supply voltages, −10 and −33 V dc. Data is put out in a 4-bit format (three-state system). Read/write cycle is 10^5 typical.

CIRCLE NO. 354

Single-chip μC contains 32 kbits of ROM



NEC Microcomputers, 173 Worcester St., Wellesley, MA 02181. (617) 237-1910. P&A: See text.

An 8-bit, general-purpose, single-chip microcomputer, μPD7801, contains 32 kbits of ROM. Additional memory includes 128 bytes of on-chip RAM and two 8-byte register banks. The device, via its 8080A compatible bus, accesses an additional 60 kbytes of external memory. Other features include 48 I/O lines and five vectored interrupts. The 5-V, NMOS device has a 2 μs instruction time. The 125 instructions of the μPD7801 provide block moves and nine addressing modes and are a combination of 8080A, Z80A and μCOM-4 instructions. Software development is aided by cross-assemblers running on NEC's PDA-80 or Intel's MDS-200 Series development systems. Hardware development is performed using a ROM-less version of the chip, the μPD7800, and a stand-alone development board, the EVAKIT-87. The μPD7800 and EVAKIT-87 are available now. The μPD7801 will be available during the second quarter of 1980 and will be priced at under $20 in quantity.

CIRCLE NO. 355

Monolithic IC contains four timing circuits

Exar, 750 Palomar Ave., Sunnyvale, CA 94088. (408) 732-7970. $1.42 (100 qty).

Four timing circuits on a monolithic IC, XR-558 and XR-559, offer board space and cost savings over single timer designs. The quad circuits, available in military and industrial temperature ranges, work in industrial controls and sequential timing applications. Each timer section produces independent time delays ranging from microseconds to several minutes. Each section has a separate output and separate timing and trigger control. All four sections share a reset control. Since they are "edge-triggered" devices, each timer section can be cascaded without use of coupling capacitors. XR-558 has open-collector outputs capable of sinking up to 100 mA. XR-559 has emitter-follower outputs capable of sourcing up to 100 mA each. Both circuits are pin-compatible replacements for the NE-558/NE-559 family of quad timers.

CIRCLE NO. 356

Application Notes

Bubble memories

A Total System Solution to Magnetic Bubble Memory Applications, eight pages, covers the concept of bubble memories (and how they compare to other memory devices); an examination of both Intel's 7110 and the 1-Mbit bubble memory; and the support electronics family. Intel, Santa Clara, CA

CIRCLE NO. 357

LCDs

LCDs: Principles of Operation, Construction and Applications covers mechanical and electrical characteristics, applications and mounting of LCDs. The five-page note includes circuit diagrams and figures. Beckman Instruments, Display Systems Div., Scotsdale, AZ

CIRCLE NO. 358

AM-FM measurements

A 27-page application note covers high accuracy AM-FM measurements. Topics include the effects of noise and spurious responses, AM detector linearity and envelope distortion, and FM detector linearity and carrier shift on overall measurement accuracy. Boonton Electronics, Parsippany, NJ

CIRCLE NO. 359

Motor control equipment

Typical Wiring Diagrams for Manual and Magnetic Full Voltage Starters, 40 pages, is a general guide to some of the useful ways Allen-Bradley's manual and magnetic across-the-line starters may be applied. Allen-Bradley, Milwaukee, WI

CIRCLE NO. 360

Electromagnetic contactors

Characteristic values of contactors, their relevance for testing and practical applications are described in a 12-page technical paper. Klocker-Moeller, Natick, MA

CIRCLE NO. 361

New Literature

Power semiconductors

Specifications of more than 1200 power switching transistors, rectifiers, zener diodes and varactors are featured in a 394-page catalog. Each product is described with graphs and tables showing performance characteristics and specifications. TRW Power Semiconductors, Lawndale, CA

CIRCLE NO. 362

Oscilloscopes, counters

Technical specifications and illustrations of all current Philips products marketed in the U.S. and Canada are contained in a catalog. Products include oscilloscopes, counter/timers, pulse generators, logic analyzers and logic scopes. Philip Test & Measuring Instruments, Mahwah, NJ

CIRCLE NO. 363

Span line test set

The Model 274A span line test set for T-carrier line monitoring and APS testing is described in a bulletin. Bowmar/Ali, Acton, MA

CIRCLE NO. 364

Microelectronic packages

Specifications, tables and dimensional drawings of microelectronic circuit packages are shown in a catalog. Airpax, Cambridge, MD

CIRCLE NO. 365

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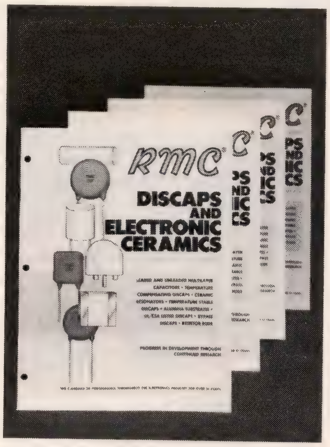

Capacitors

Monolithic, low-voltage subminiature, temperature-compensating, high-voltage and high-dielectric capacitors are described in a 36-page catalog. Specifications, such as size, rating, tolerance and temperature characteristic curves, are included. RMC-Radio Materials, Chicago, IL

CIRCLE NO. 366

Resistive components

A series of technical publications presents information on little known or commonly misunderstood facts associated with precision resistive components. Vishay Resistive Systems Group, Malvern, PA

CIRCLE NO. 367

Solid-state relays

Specifications of solid-state relays and I/O modules are described in a catalog. Tables show line voltage, maximum load current and one-cycle surge current limits for all models within each series. International Rectifier, Crydom Div., El Segundo, CA

CIRCLE NO. 368

Array processors

The use of array processors with Data General's Eclipse AP/130 and S/250 computers is described in a six-page brochure. Data General, Westboro, MA

CIRCLE NO. 369

Coaxial connectors

Specifications and drawings on the SMA/SMB, SMC and NanoheX microminiature coaxial connectors are shown in a 36-page catalog. Sealectro, Mamaroneck, NY

CIRCLE NO. 370

Power tools

Flexible shaft-driven miniature power tools are featured in an eight-page catalog. The Foredom Electric Co., Bethel, CT

CIRCLE NO. 371

Pressure transducers

Specifications and descriptions of the P700 series of strain gauge pressure transducers are contained in a bulletin. Schaevitz Engineering, Camden, NJ

CIRCLE NO. 372

Printers

Photographs and specifications of dot-matrix impact printers are given in a six-page brochure. Eaton LRC, Wakefield, MA

CIRCLE NO. 373

Servo recorder

A servo recorder, designed for single or three-phase recording of ac voltage and current, is described in a two-page bulletin. Esterline Angus Instrument, Indianapolis, IN

CIRCLE NO. 374

Multimeters

Features of Series 3000 3-1/2-digit portable multimeters are described in a six-page brochure. Beckman Instruments, Advanced Electro-Products Div., Fullerton, CA

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Power supplies

An eight-page catalog describes and illustrates 175-W quad output switching power supplies. Deltron, North Wales, PA

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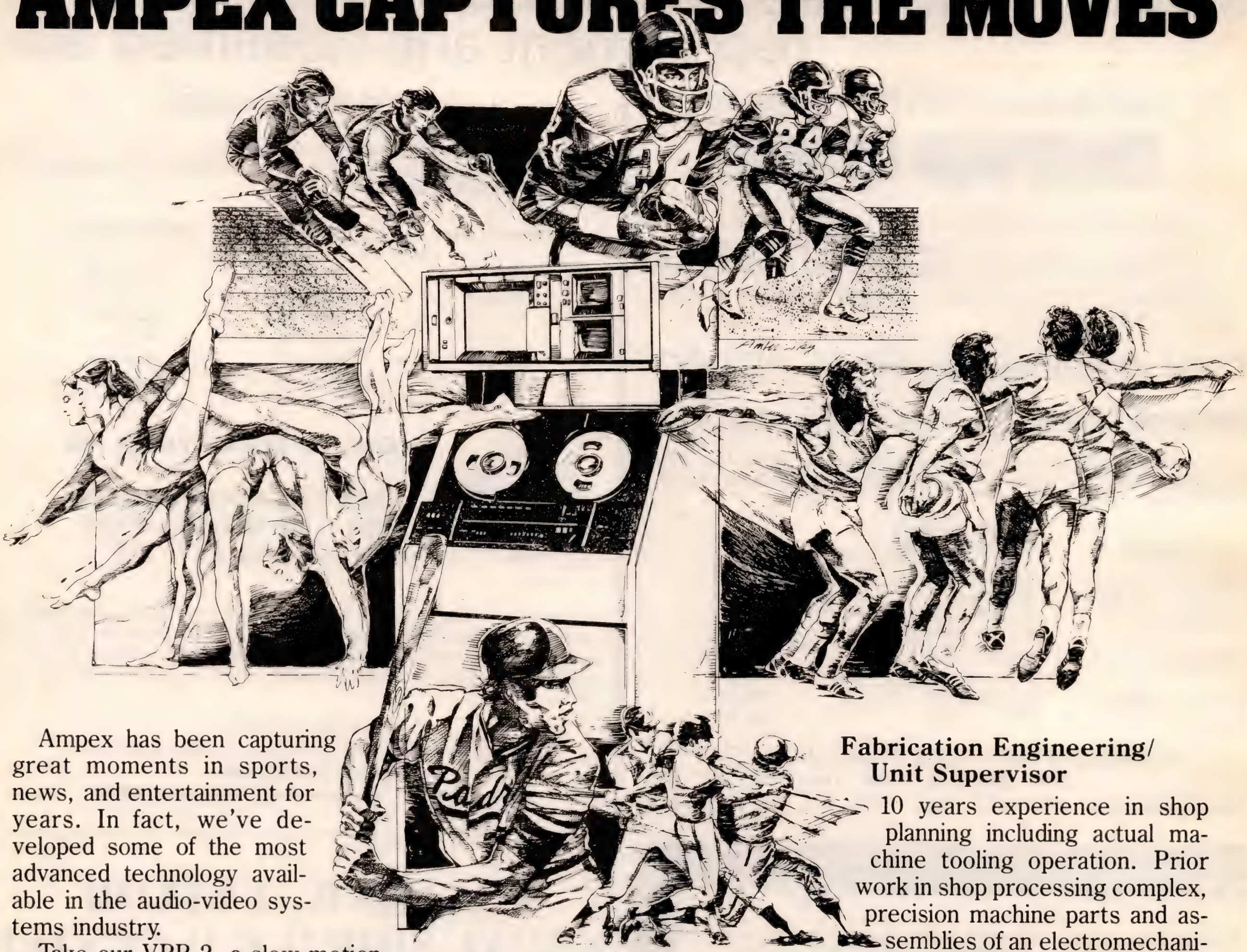

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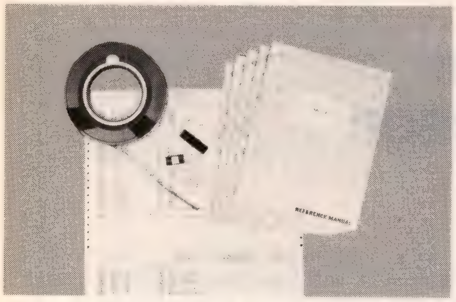

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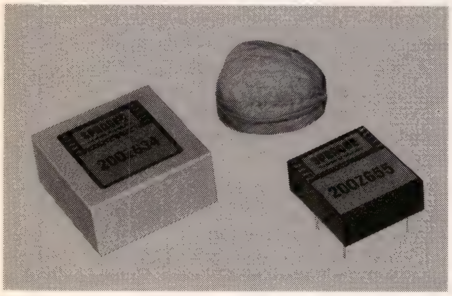

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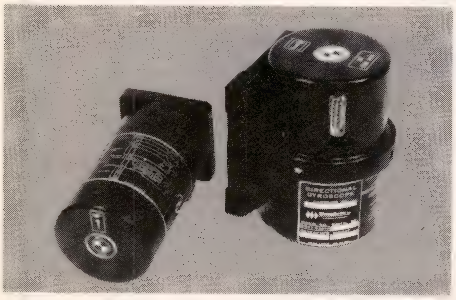

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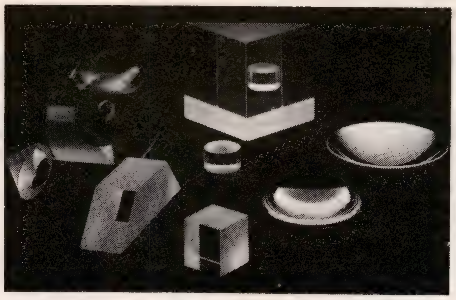

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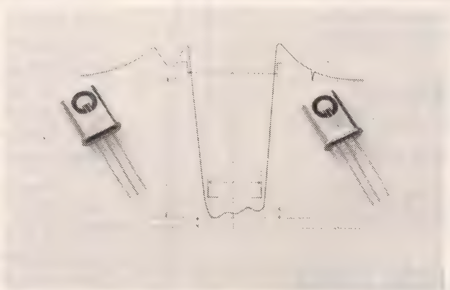

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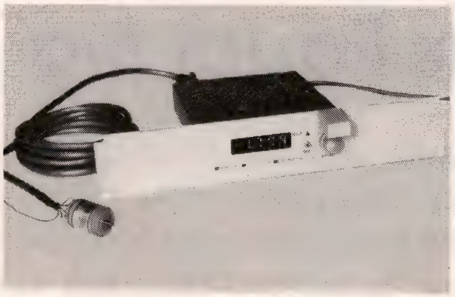

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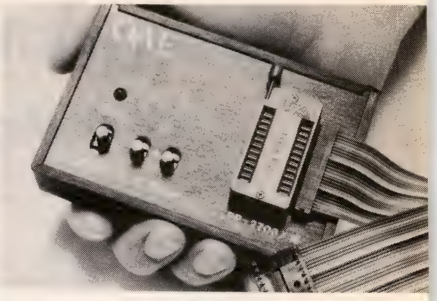

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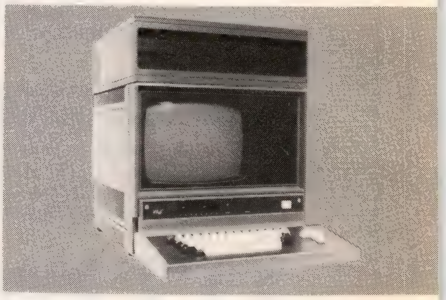

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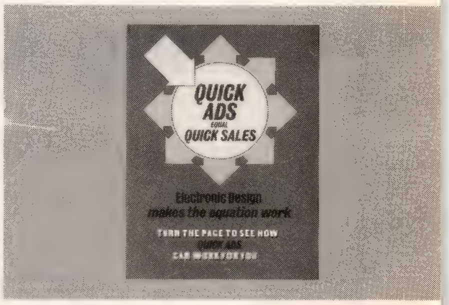

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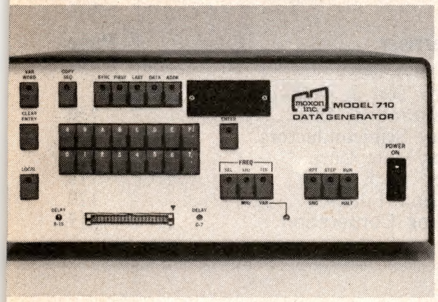

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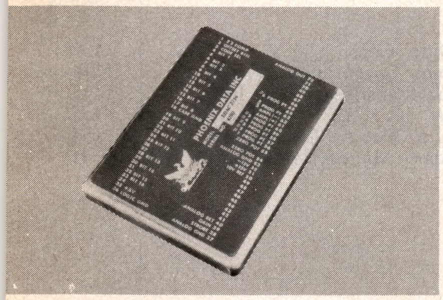

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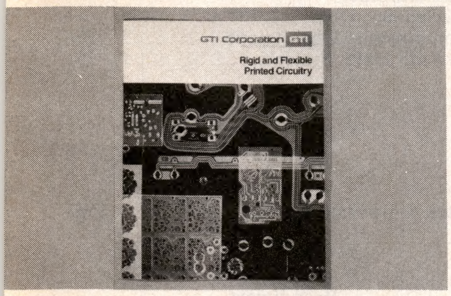

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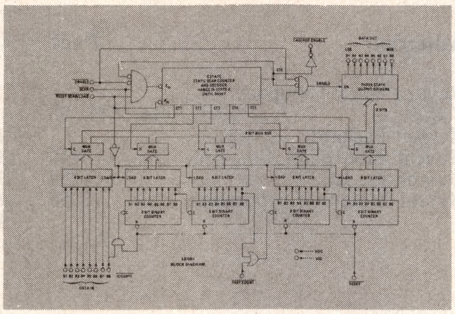

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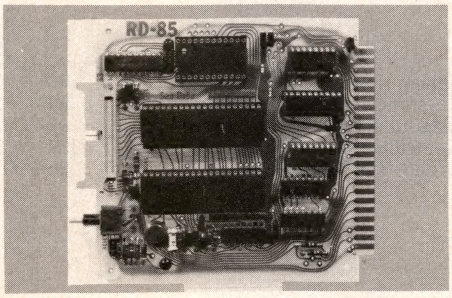

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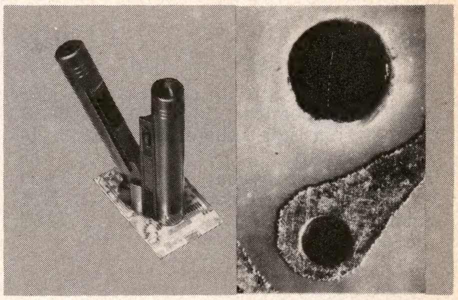

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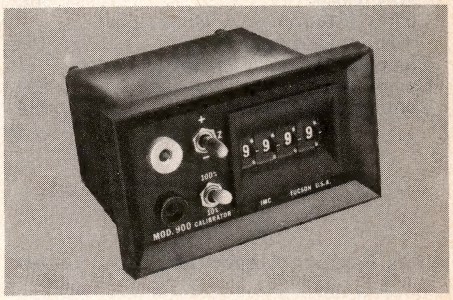

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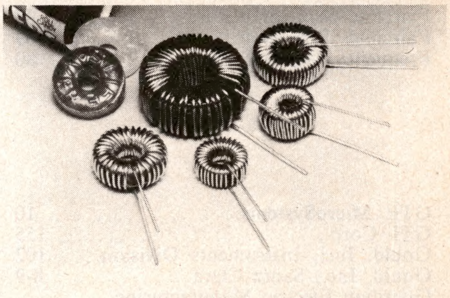

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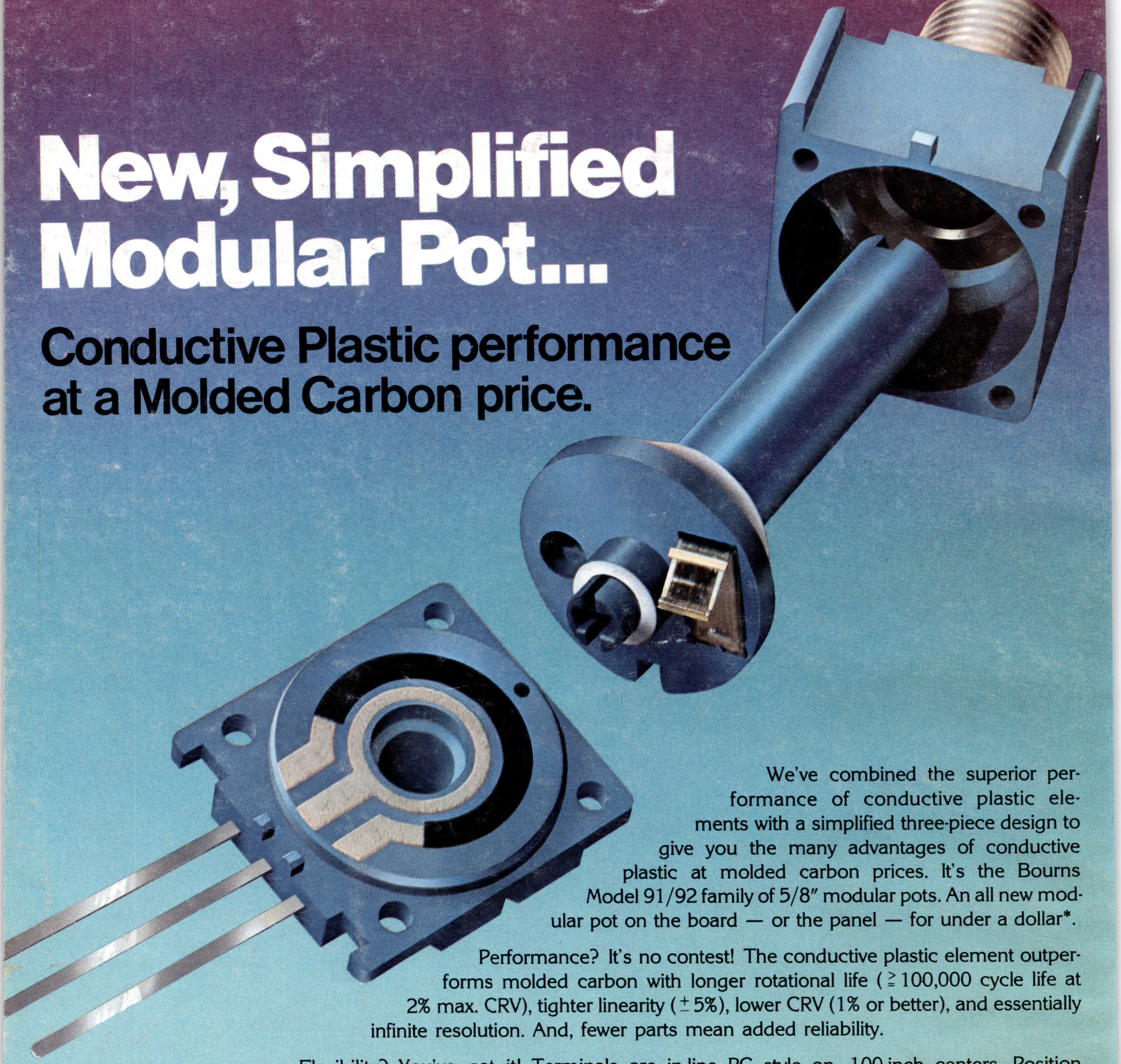

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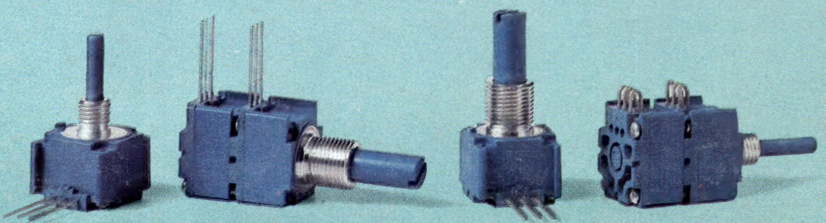

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